Dairy Greenhouse gas Abatement

Strategy calculator

(DGAS)

Adviser version User Manual

Version 1.4

August 2011

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Dairy Greenhouse gas Abatement Strategies (DGAS) calculator

The Dairy Greenhouse gas Abatement Strategies (DGAS) calculator has been developed by the Tasmanian Institute of Agricultural Research (TIAR), through funding by the Department of Agriculture, Fisheries and Forestry and Dairy Australia, to address the greenhouse gas emissions concerns of the Australian dairy industry. It draws upon the Department of Climate Change National Inventory Report 2006 submission to the UN Framework Convention on Climate Change and incorporates the most recent scientific knowledge in its modelling. This manual refers to DGAS version 1.3, March 2011. The model is constructed as a Microsoft Excel Workbook and incorporates MSForms for ease of use.

Purpose of Software

DGAS software is intended to give the User an understanding of the greenhouse gases emitted from their enterprise, both in absolute terms and relative to milksolids produced. The gases, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are multiplied by 1, 21 and 310, respectively, so as to be expressed in tonnes of CO_2 equivalents. These are then totalled and compared to the tonnes of milksolids produced by the enterprise.

The software is specifically engineered to enable the User to vary the key inputs to the enterprise and compare the effects of changes on emission levels. Both baseline and a strategy data are processed and the outputs graphed for easy comparison. A report of inputs and results can be printed out or saved as an MSExcel spreadsheet.

Due to the detailed inputs required, the adviser's version of DGAS is targeted towards researchers, advisers and consultants. The farmer version of DGAS has been simplified and therefore could be more suitable for farmers to use.

Updates from version 1.2

There has been many improvements and changes made to DGAS since the release of version 1.2. These are listed below in no particular order. Since releasing version 1.3 in June 2011, we were asked to review the nitrification inhibitors and so have made some alterations to those two abatement strategies. More information regarding these are in this manual.

Changes include:

1. Inclusion of the current version and date of release in the top right corner of the introduction page.
2. Changes to manure CH_4 emissions due to changes to the manure methane conversion factor (MCF) for milking and non-milking dairy cattle. These changes will affect all farms and locations and therefore the overall results for all farm systems. Users can either define the actual farm management practices for the farm being assessed (preferred method) or use the previous MMS1- Pasture-based system factors (less preferred method). We introduced this option of User estimated as it more accurately reflects how manure is handled on individual farms, as opposed to the previous default state-based averages. The User can now define the amount of time spent in the dairy and on feedpad and/or loafing areas where manure is deposited and then handled. This data is used to estimate the MCF for the milking herd and for all other stock classes in addition to estimating the amount of waste handled by up to five different manure management systems (i.e daily spread, lagoon, dry lot, solids storage and voided onto pastures during grazing). **We suggest users refer to the section titled manure management in this manual (page 18) when familiarising themselves with this updated version as they need to access two new data entry pages for the milking herd and other stock classes and implement the copying of the baseline data to the strategy farm via a different mechanism than for copying all other data from the baseline farm to the strategy farm.**
3. Changes to indirect N_2O emissions for fertilisers and animal wastes. After discussions with Dr Richard Eckard (methodology expert), it was clear that the risk of leaching/runoff of N fertilisers applied to dryland pastures/crops and animal waste was too low for some regions, especially NSW, QLD, SA and WA. Increases will also occur for VIC and TAS but to a lesser extent as these states

already had high emission factors for this source of indirect N_2O emissions. Therefore for all farms and all locations, the indirect N_2O emission will increase due to the changes in DGAS version 1.3. Therefore we suggest when reporting any results, that it is made clear that the version of DGAS used to estimate GHG emissions is version 1.3.

4. Change in the equation to calculate enteric CH_4 for non- milking herd stock classes, resulting in a slight reduction in enteric CH_4 for non-milking stock.
5. Incorrect emission factor for phosphorus-based fertilisers fixed. This will increase the pre-farm fertiliser GHG emissions for farms with phosphorus fertiliser applications.
6. Fixed the radio button option for fertiliser application rates so that the user can use kg/ha for the baseline farm and tonnes/annum for the strategy farm. Previously you needed to use one or the other for baseline and strategy farm.
7. In the Fats and Oils strategy help message- reduced the percentage of reduction in CH_4 from 5.6 to 3.5% for every 1% increase in dietary fat fed in the diet. Fats and oils can now only be fed during summer and autumn as the fat content of pastures are generally high in winter and spring, thus restricting the potential of this as an option during winter and spring.
8. Altered when condensed tannins is a viable abatement strategy to now only be winter and/or spring as opposed to year-round as in previous versions of DGAS. This has due to this strategy only being suitable when diets contain excess crude protein. Implementing the condensed tannin strategy in winter and/or spring will reduce CH_4 emissions by 10% in the activated seasons. Activating this strategy will also reduce the CP content of the diet to 18%, thus replicating the process by which tannins bind excess protein in the diet from being excreted as urine N. If however, the diet is already < 18%, there will be no change to the diet and therefore N_2O emissions as in reality, feeding a diet with < 18% CP in addition to feeding a source of condensed tannin could result in a CP deficit.
9. Added a new nitrification inhibitor strategy for spraying the inhibitor onto pastures directly after grazing, with a default 40% seasonal reduction in urine, dung and manure N for direct and indirect leached N_2O emissions. Differences in the % reduction in N_2O emissions between the direct and indirect animal waste are due to different emission factors applied to these two sources.

10. Users define the percentage of annual fertiliser that is coated with a nitrification inhibitor and effective in reducing N_2O emissions.
11. Separated indirect N_2O emissions from N fertilisers and indirect N_2O emissions from animal waste. Also added this to the Ad-hoc calculator so can assess the impact of a reduction on these two sources independently.
12. Included the sheets and cells linked to the abatement strategies at the base of the backdrop sheet for any future reference.
13. Greater information in this manual and in the help messages in DGAS regarding abatement strategies and the things to be considered when adopting the strategies. For example, when feeding dietary fats, has the user considered any changes to diet quality and/or milk production and made manual changes to DGAS to reflect these impacts?
14. As each form is opened by progressing through DGAS, the forms remain maximised to the size of the user's monitor.
15. Additional help messages for farm area and electricity and fuel consumption, with unleaded petrol to be included with diesel consumption.
16. Coding to check that the daily diet intake is within an expected range of the estimated intake required to achieve the annual milk production and/or the live weight and live weight gain for the replacements. Users have the option to either accept that their data entry is correct or can re-check and change data entry if an error has been made.
17. Coding to check that diet intakes are filled out for all 4 seasons for the milking herd. Also if stock numbers for replacements and/or bulls are entered, that the diet intakes are also filled out, otherwise incorrect estimations can occur if no annual digestibility and crude protein figures are determined. A message will appear when progressing to the results page indicating which areas need filling in.
18. Altered the layout of the results page by moving the bar chart to the bottom of the page, altering the chart to be a column graph, colour coded the column and pie charts so that all sub-sources are the same colour (i.e. all 4 N_2O emissions are blue, CH_4 are yellow), the baseline farm results is a solid column and the strategy results is a faded/ hashed column, re-worded some of the source headings to be more reflective of the source.
19. Removed the Save Results button from the results page – removed due to complications with saving formulas and formatting between workbooks. We

recommend that the User can either print the results and/or save a new copy of DGAS using the 'SAVE DGAS AS' option.

20. Altered the ETS liability to now read CH_4 & N_2O only figure to the table of results for the Baseline and Strategy farm. This is due to the changes to the government policy in regards to the Australian emissions trading scheme since the last DGAS release.
21. Added a button to hide/unhide the Ad-hoc calculator when not in use.
22. Altered the economics page to reflect the more recent policy changes regarding agriculture, emissions trading and carbon credits. Farmers may now have the opportunity to gain carbon credits for management practices that meet the rigorous requirements under the Carbon Farming Initiative (CFI). It is not clear if the abatement strategies currently available in DGAS will meet the requirements of the CFI in terms of additionality, permanence, avoidance of leakage, measureable and verifiable, scientifically sound and meets international consistency. The economics calculations also do not take into consideration the additional costs in terms of time required to meet the requirements needed on-farm to meet methodology requirements. Therefore the economics page should still be used with a high degree of caution when reporting to farmers the economic benefits of adopting abatement strategies, especially in light of carbon policies.
23. General tidying up of headings, data entry, greater explanation for some of the help messages etc.
24. Data entry sheet included as an appendix in manual to use when collecting data from farmers (Appendix 1).

System Requirements

The system is constructed using the Microsoft Office environment and has been tested using MS Excel 2000, 2003, 2007 and 2010. The libraries used in the programming of the interface forms are compatible with Office 97, 2007 and 2010. All development has been done on Intel-based machines running Microsoft Windows XP. The software has not been tested on other operating systems or hardware, but should run on systems that support Microsoft Office 97 or later.

It has come to our attention that computers with Windows 7 Professional 64 bit may have issues with opening and running DGAS. All attempts have been made to

overcome this issue, but to date we have not been able to overcome the coding differences between 32 and 64 bit. There have also been issues relating to not being able to view the full screen. We suggest selecting a screen resolution of 1440 by 900 as described in the Screen resolution section alter in the manual.

Enable macros

The security settings of Excel (Office2000: Tools/Macro/Security, Office2003: Tools/Options/Security) should be set to Medium. When you open the DGAS Excel workbook you will be asked whether or not to enable macros. You should do so (“Enable Macros”), for the interface forms to run. After a brief pause, the *Farm Inputs* form will appear and the spreadsheet will be minimised.

The security settings of Excel 2007 (Developer/ Macro Security/ Macro settings) needs to be set to enable all macros before DGAS will run. After a brief pause (approximately 10 seconds), the *farm inputs* form will appear and the spreadsheet will be minimised. You should not need to click the Restart button when opening up the calculator for the first time.

Exiting DGAS

To exit the system, the Excel workbook must be closed. At this point any changes you have made can be saved. If you do not wish to overwrite previous data and still wish to save current data, then use “SAVE DGAS AS” and save as a different DGAS Excel workbook. Please note the information located in the Save Results section in this report (page 10) pertaining to issues with various formats of MS Office Excel. DGAS should only be saved using the MS Excel 97-2003 format (*.xls), irrespective of which format is currently available to the User for saving (i.e. Don’t save as MS Excel 2007 [*.xlsx, *.xlsm or *.xlsb] formats)).

At times when multiple copies of DGAS are open, the macros driving the calculator can become interfered with, thus making the calculator unworkable. Therefore we recommend two steps. Firstly when opening up DGAS for the first time, use the “SAVE DGAS AS” option and only work from this working version; keep the original DGAS version filed separately. Secondly minimise having two or more copies of DGAS open

concurrently. If a debug message does appear, there is little that can be done, so delete that file, reopen the original DGAS file and resave as the working version of DGAS.

Screen resolution

We suggest that if you are unable to view the graphics, adjust the resolution to the preferred settings of 1440 by 900 (right-click mouse when in a clear area of the desktop, select Properties, then Settings, reduce the resolution and apply settings).

Workbook View

The DGAS MSExcel file is editable, to enable further refinement of the model. There are three functional categories of worksheets in the workbook. In order to protect the workbook from inadvertent damage, all sheets except the “BackDrop” sheet are hidden by the macros driving the forms (Figure 1.). If the User closes the forms without deliberately navigating via “EXCEL” buttons, the other worksheets will remain hidden. These buttons are found on the *Farm Inputs* form (the form that automatically opens when the DGAS file is opened) and the *Results* form.

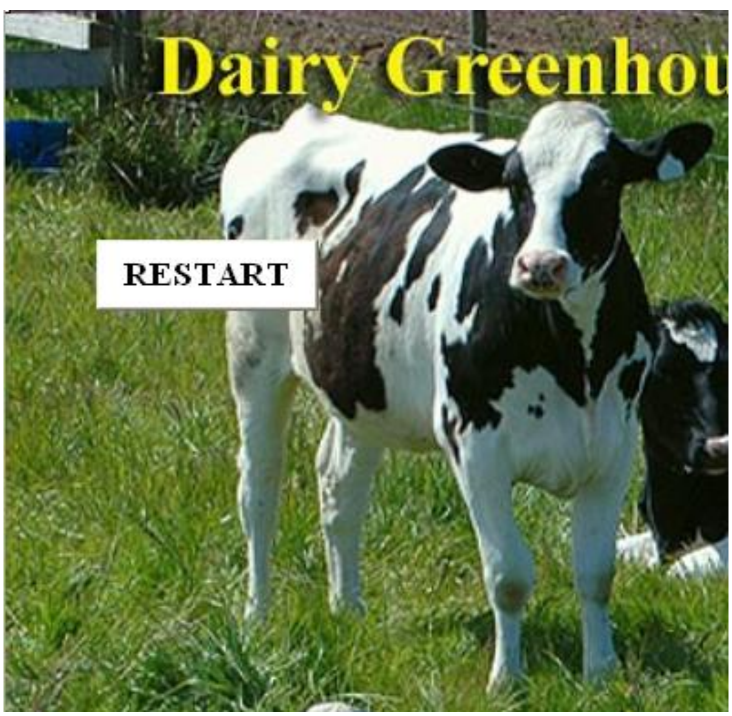


Figure 1. The BackDrop worksheet is the only sheet to be visible unless form-based navigation is used. The restart button will launch the userforms.

Once the Excel worksheets are visible, it is possible to swap freely between the forms and the worksheets via the restart button on the “BackDrop” sheet. The User must deliberately choose to open the worksheets with a view to editing. Such a step is not to be taken lightly and should be done using a copy of the DGAS file.

Introduction page

After DGAS is opened, but before the input sheets appear, an introduction page will appear. There are four areas of information which a 1st time user needs to become familiar with on this introduction page. These are navigation between forms and between herd diets, saving DGAS and printing results. To close the introduction page and proceed to the first input sheet, click the cross in the top right hand corner of the page. After the User has become familiar with these four issues, they can elect to not see the introduction any more by ticking the ‘Do not show the introduction again’ box at the bottom of the page. Otherwise this page will appear each time that DGAS is opened. If the User wishes to view the introduction page after the box has been ticked, they can undo the tick by changing TRUE to FALSE in cell B123 on the BackDrop worksheet.

Input Sheets

Two input worksheets are used to store the descriptions of the baseline scenario (“FarmSheet” and “HerdSheet”), two mirror sheets are used to store the descriptions of the abatement strategy scenario (“Farm_A_Sheet” and “Herd_A_Sheet”) and one worksheet is used to enter the economics (“EconomicsSheet”). Pre-farm emissions are calculated on the farm sheets. In addition, a “Milkers Manure” and an “Other stock Manure” sheet have been added vai access from the “*Farm Inputs*” sheet. The data from these two sheets are transferred onto the “ManureCalculations” sheet to estimate the integrated manure methane conversion factor (MCF) and the % of waste to each manure management system.

Calculator Sheets

The models used for calculating the emissions resulting from the enterprise of dairying are divided into “Enteric Methane”, “Fecal Methane”, “Nitrous Oxide-Fecal”, “Nitrous Oxide – SoilsFerts”, “Trees” and “Electricity & Diesel”.

Output Sheets

The penultimate worksheet in the workbook is the “ResultsSheet” where the output for the two scenarios is separated and graphed. The 3rd last worksheet, “PrintSheet”, is a summary of both the inputs and the results. It can be saved separately and printed – both from worksheet view and, more easily from the *Results* userform. The last worksheet is the FeedQuality table referencing various feed type qualities.

Structure of Software

The software has, at its core, 18 “worksheets” in an MSExcel “workbook” and six “userforms”. The 15 “worksheets” sheets are the functional components of the software (Figure 2.). Five userforms are devoted to accepting the Baseline, Strategy and Economics inputs and one is used to access the results.

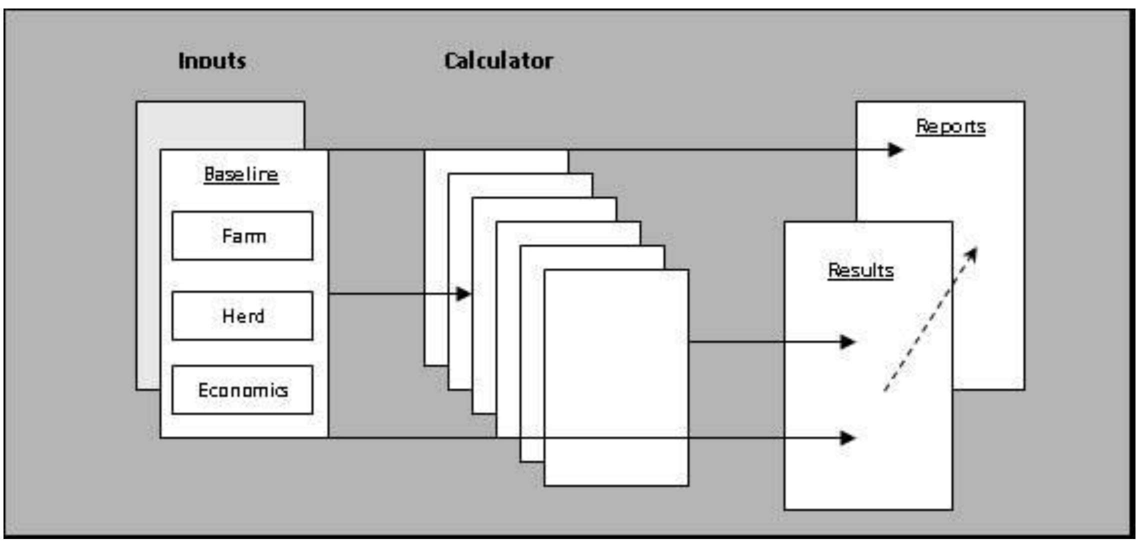


Figure 2. The functional operation of DGAS. Baseline and strategy inputs are passed to the calculator and to the results and report pages. The calculator applies transformations before passing that data to the results page. Results are included in the report.

Navigation

The software is designed to take the User through a specific path of data entry via six userforms. The User is asked to enter details of the current farm practices first. These are divided into *Farm Inputs* (the first form to open when the User chooses “Enable Macros”), *Herd Information* and *Economics*. The current farming practice data is referred

to as the “Baseline” scenario and is associated with **green** navigation buttons (see Figure 3.).

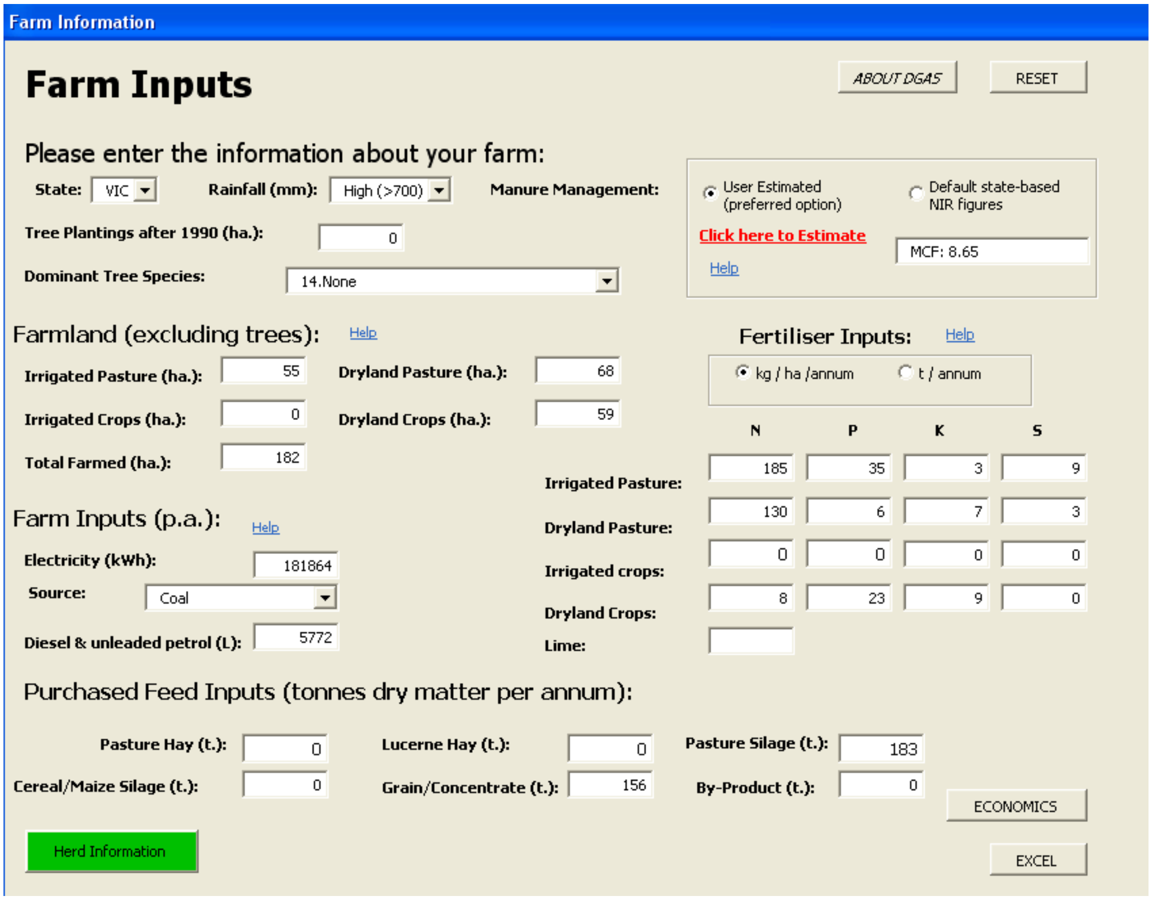


Figure 3. The first data input form – enter the current practices for the farm here. To enter the current herd information, click the green button.

After entering the farm information, selecting the **green** herd information button will open the herd information form. Having entered the herd information, it is possible to go back and edit the farm inputs or navigate to the *Results* form, associated with **red** navigation buttons. You can view the results and after reviewing, you can navigate back and edit the *Herd Information* form by selecting the back button or by closing the page by selecting the “X” in the top right corner of the userform. Once on the *Herd Information,* you can then navigate back to *Farm Inputs* form by selecting the **green** herd information button (Figure 4.).

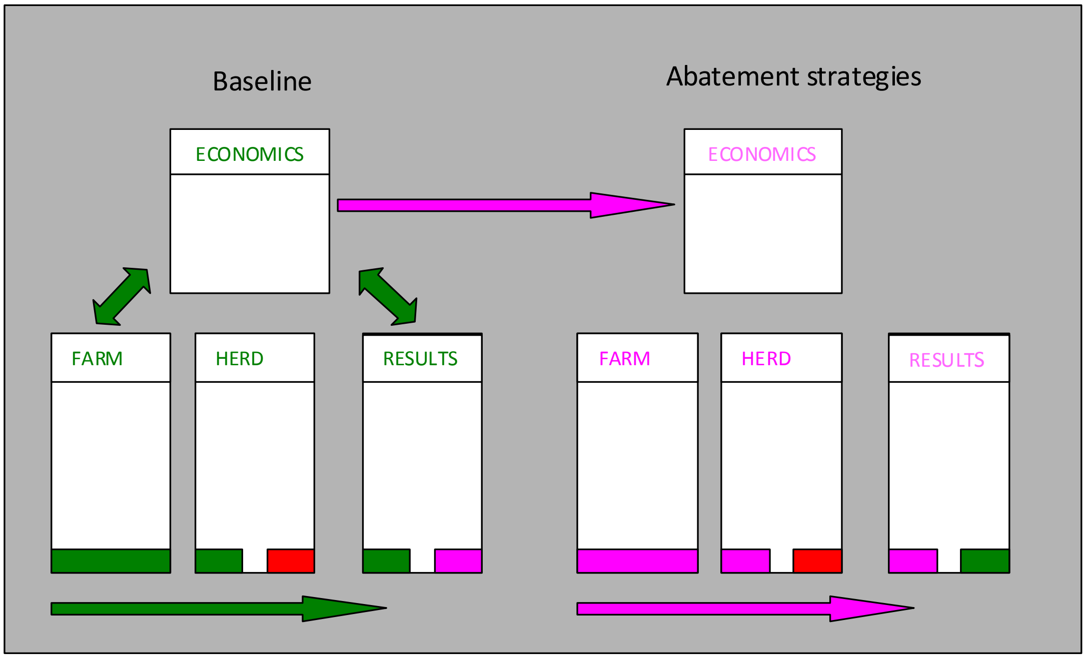


Figure 4. Navigation sequence of the userforms. Baseline information is entered before the User can enter an abatement strategy. Results are viewed after each scenario. The results form permits navigation between scenarios.

The User can enter their economics data from either the *Farm Inputs* form or the *Results* form. To enter the *Economics* form, click on the Economics navigation button at the bottom right hand corner of the *Farm Inputs* form. On the *Economics* form, you can enter the farms' annual financial information. This form can be cleared, closed to return to the *Farm inputs* form and the figures can be transferred to the *Economics Strategy* form. To navigate to the *Economics Strategy* form from the *Economics* form, select the **pink** navigation button. While the financial status of the farm could be of value in determining the effects of adopting abatement strategies on farm profit, it is not essential that the economic data is entered. More information regarding the *Economics* form will be discussed further in this manual.

Once the User is satisfied that the baseline farm data is accurate, the User is then able to enter a speculative scenario referred to as a "Strategy" or "Abatement Strategy" for both the farm inputs and herd information. These are associated with **pink** navigation buttons. The "Farm Strategy" button closes the *Results* form and takes the User to the *Farm Input Abatement Strategy* form. From there it is possible to move to the *Herd*

Abatement Strategy form and then forwards to the *Results* form where output from the baseline and the abatement scenario can be compared, printed or saved.

The User is able to navigate from the forms to the Excel workbook by clicking the "EXCEL" navigation button found on the *Farm Input, Farm Inputs Abatement Strategy* and *Results* forms. This allows the User to assess the equations and emission factors associated with calculating the GHG emissions.

Form Inputs and Controls

The baseline and the strategy *Farm Input* forms have identical data entry fields, with only a small difference in the two *Herd Information* and *Economics* forms. The baseline *Herd Information* form allows the User to copy baseline data for both the farm and herd to the strategy forms as a convenience. The *Economics* form can also be copied from the baseline to the strategy form by selecting the Copy to Strategy button. The *Herd Information Abatement Strategy* form allows the addition of fixed abatement strategies as well as altering herd and diet information. The *Economics Strategy* form has one farm income and one farm expenses box to allow the User to indicate the changes in finances associated with the abatement strategy assessed.

Validation

A series of dropdown lists allow the User to select options that require text. All other data requires the User to enter numbers. Text characters cannot be entered (Figure 5.).

Figure 5. Fields requiring numbers will not accept text characters. When the User clicks OK on the error message, the field is reset to zero.

If the User moves to a new form without adding all necessary data, they will be allowed to move, but will be shown a list of the missing data (Figure 6.). This warning is only generated if the User has filled in at least one of the essential fields. Otherwise the User is assumed to have reset the form.

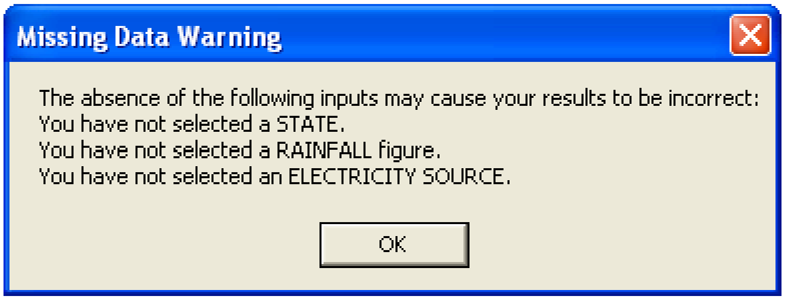


Figure 6. Leaving the farm input baseline and strategy forms will raise a warning if essential data is omitted.

Tips and help

Where appropriate, tips for data entry (such as unit conversions and expansion of abbreviations) will appear if the mouse hovers over an input field or label. More extensive assistance is also provided where complex decisions are required and can be obtained by clicking on the blue "Help" beside complex fields (Figure 7.).

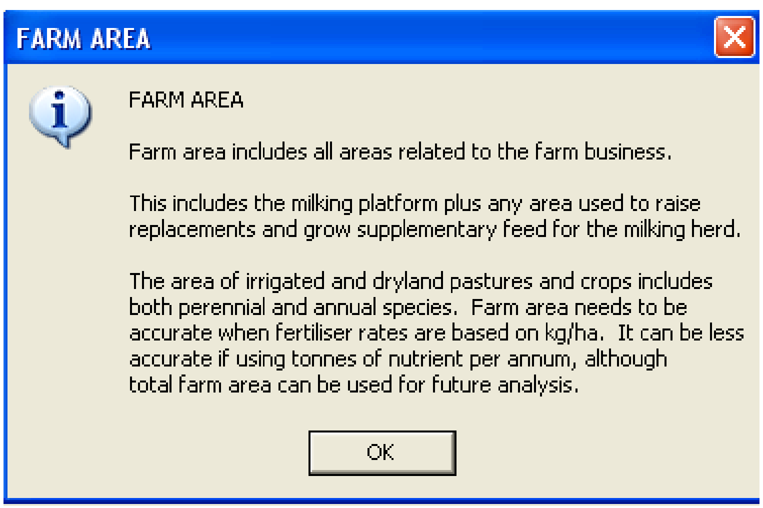


Figure 7. Help for selecting the Manure Management System from the dropdown list.

Reset button

If you wish to clear data from the entire form, click the “RESET” button located at the top right hand corner of each form. The User will be warned and able to cancel the action before data is deleted (Figure 8.).

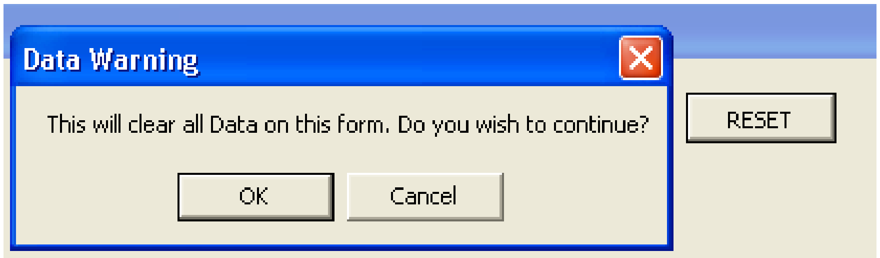


Figure 8. The User has an opportunity to reconsider when clicking the reset button.

Excel button

The “EXCEL” button allows the User to close the form interface and open the MSExcel workbook. All the usual menu items, formulas, format options, etc are available to the User. The sheets may be “protected” but can be unprotected via the Tools/Protection/ menu options.

WARNING: Changes to the workbook may destroy the calculator!

The calculator is highly dependent upon the values in specific cell locations. Even inserting or deleting a row is likely to cause damage that will be difficult to repair. It is best to experiment with a copy of the file first before making any long term alterations. The userforms have similar dependencies since data must be recorded in specific locations.

Print results

The “PRINT” button will compile a report on the “PrintSheet” worksheet and send a print instruction to the default printer. It uses the print setup and print configurations of the Excel program running the DGAS file, and thus of the computer running Excel. The report is set out to fit into 5 or 6 landscape A4 pages. The User is able to reconfigure all of this by altering the layout of the “PrintSheet” worksheet. The page set-up should be in landscape. The margins should be customised so that the top and bottom are 2.5 cm, the left and right are 1.0 cm and the header and footer are 1.3cm.

WARNING: It is suggested that the User only alter the formatting if they absolutely must and that they do so ***only on a copy*** of the file. The report draws on all the input values as well as a copy of the actual bar graph and pie chart. In particular, the nutrition details for the herd are copied to specific blocks of cells at the end of the sheet. Empty data is omitted.

SAVE DGAS AS

The “SAVE DGAS AS” button is found on the *Results* userform. Click on the “SAVE DGAS AS” button and you will be directed to the standard Excel SaveAs dialog box. You can change the name and location of the file to be saved as desired (Figure 9.).

Although the calculator has been tested on various MS Office Excel formats, including 2000, 2003 and 2007, there are issues relating to saving DGAS in the 2007 format. Therefore, irrespective of the format of Excel, **DGAS must be saved** as a MS Excel 97-2003 format with the xls extension (Figure 9.). **Do not** save it using the Excel 2007 Workbook (*.xlsx), Excel 2007 Macro-enabled Workbook (*.xlsm) or Excel 2007 Binary Workbook (*.xlsb) formats as this has the potential to corrupt the file.

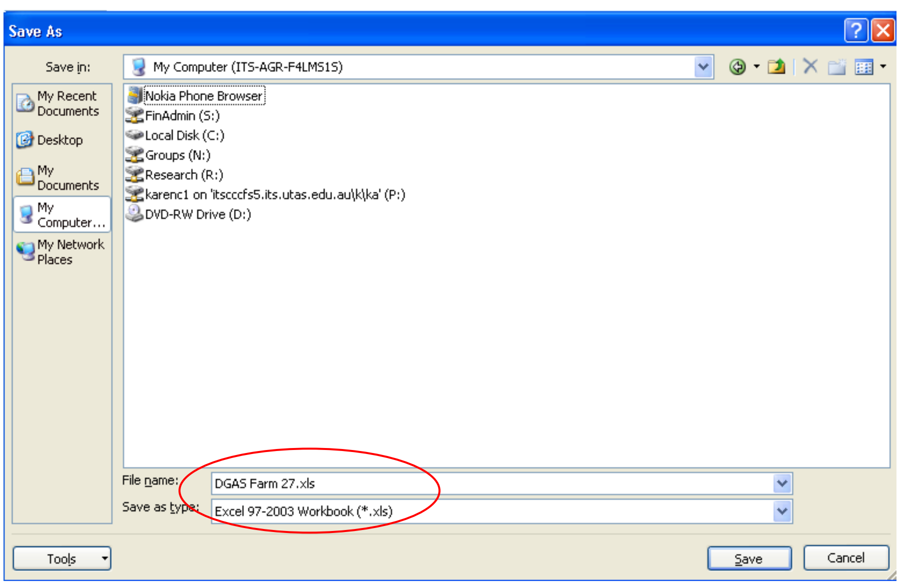


Figure 9. When saving DGAS, always check that the format used to save it is the Excel 97-2003 Workbook format as other formats can corrupt the calculator.

DGAS User forms

Farm Inputs

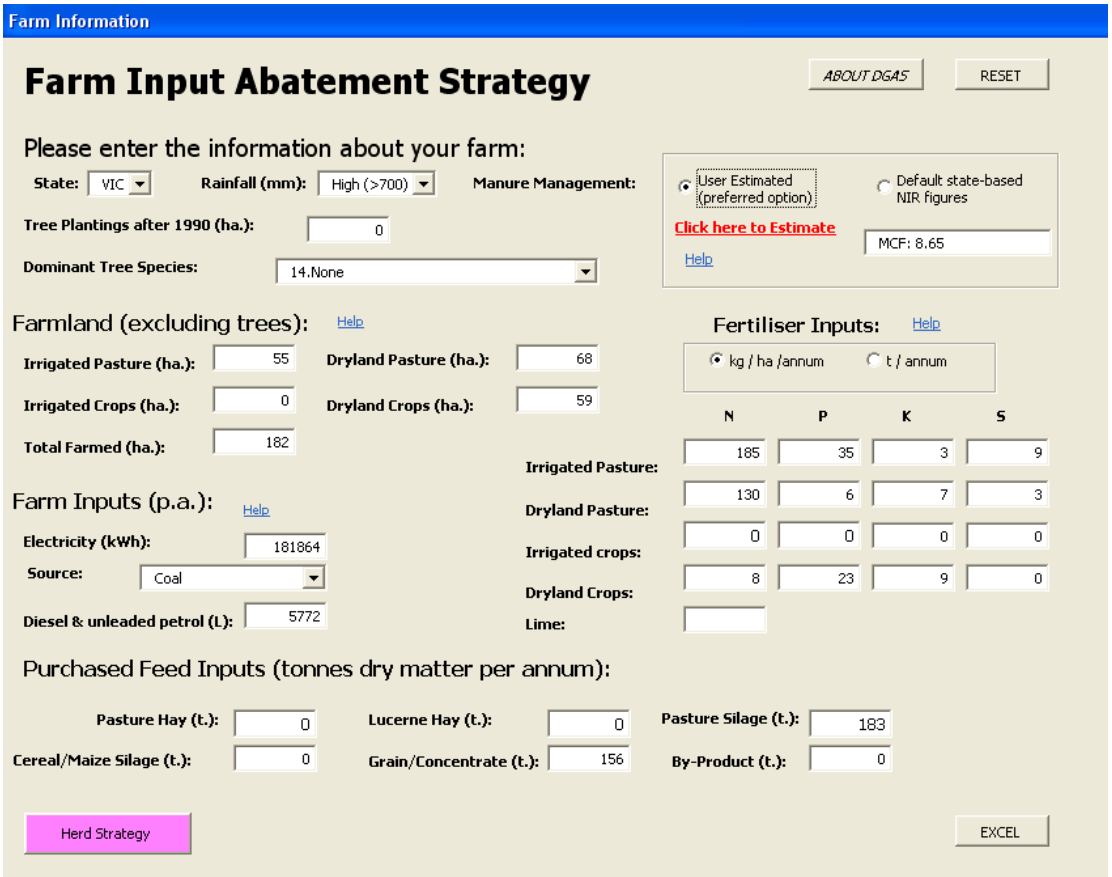


Figure 10. The Farm Input Abatement Strategy form (replication of the Farm Inputs Form). The only data entered using the keyboard is numeric. All text input is selected from dropdown lists. To access the sheets to calculate the methane conversion factor, the use needs to click on the Click to Calculate Manure Management Factor link. Data is logically grouped and can be navigated using both the tab and enter keys.

The *Farm Inputs* form contains all the information regarding the physical aspects of the farm (Figure 10. shows the farm inputs abatement strategy page which is a mirror image of the farm inputs page, with the exception of the coloured navigation box). The “pre-farm” emissions from the CO_2e emitted with the production of grain, fertiliser and purchased feed inputs are calculated from the data entered on this form. The nitrogen fertiliser data is also used to determine the direct and indirect N_2O- fertiliser emissions.

Manure Management

This section of DGAS has undergone major changes since version 1.2 due to concerns with the current method of selecting one of four options. Previously, the MMS1 option represented the current state-based factors, with 88.5 to 92.0% of waste voided onto pastures during grazing, with 2.0 to 10.0% of waste handled via a pond/lagoon system, with 1.0 to 7.0% of waste spread daily and either 0 or 0.5% of waste handled as a liquid/slurry. These factors were then used in conjunction with the methane conversion factor (MCF) of each system to estimate an integrated MCF. In attempting to reflect other farm systems, in particular partial and total mixed ration feedlots, in versions 1.0 to 1.2 of DGAS we introduced the option of three other systems (MMS2, MMS3 and MMS4) with varying proportions of waste destined to a pond/lagoon system as opposed to voided onto pastures during grazing. However, we felt that these still did not accurate reflect the management of manure for these farms. In addition we also did not agree with the allocation of waste to the different manure management systems as part of the MMS1 farm default was reflective of all pasture-based farm systems.

To overcome this, Users have two options when defining the integrated MCF and % waste to the various manure management systems. If Users do not fill in the manure management section (either by choice of if just missed), a message will appear to inform users that they are required to either select the default state-based factor or preferably, fill in the information regarding the handling of manure for the milkers and all other stock (Figure 11.).

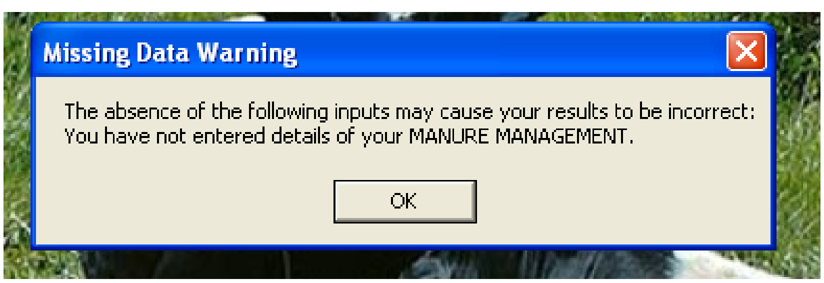


Figure 11. Missing data warning for the manure management system

The User can either estimate the farm's MCF by defining the management practices in place on the farm in question (preferred method) or can use the default state-based NIR figures (less preferred method). The MCF value used for each manure management system for either method is based on the 2006 IPCC Guidelines for National

Greenhouse Gas Inventories report (http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html). The Australian NIR report (http://www.climatechange.gov.au/publications/greenhouse-acctg/national-inventory-report-2009.aspx) considers Queensland as a warm region, while all other locations are considered in the temperate region so this differentiation between the states has been maintained in DGAS (Table 1.). Based on the MCF of individual manure management systems and the fraction of waste allocated to these individual manure management systems, an integrated MCF value is determined and used in the Fecal CH_4 equations. In addition, the fractions used as then also used in the Fecal N_2O and the Void & Spread N_2O equations.

Table 1. Manure methane conversion factor (%) for the various manure management systems in DGAS for temperate and warm regions.

	Voided onto pastures (%)[1]	Daily spread (%)	Solid storage (%)	Dry lot (%)	Liquid/Slurry (%)	Anaerobic lagoon (%)
Temperate	1.0	0.5	4.0	1.5	35	90
Warm	2.0	1.0	5.0	2.0	65	90

[1] Voided onto pastures maintained at 1 and 2% as opposed to 1.5 and 2.0% in the IPCC report, based on all other stock having an methane conversion factor of 1% when 100% manure voided onto pastures during grazing (Australian NIR report).

Therefore while the Default state-based NIR figures may be an easier method to adopt, we strongly suggest taking the time to fill out the questions required for the User Estimated option. By clicking on the Click here to Estimate link (Figure 12.), Users are redirected to an excel spreadsheet titled Milker Manure. A series of questions and drop-down list options has been set up to collect the information needed to estimate the amount of manure handled by up to five options and from these, estimate the integrated MCF. Green cells represent where numbers are required, yellow cells represent dropdown lists where an option is selected while blue cells represent cells where no data entry is required.

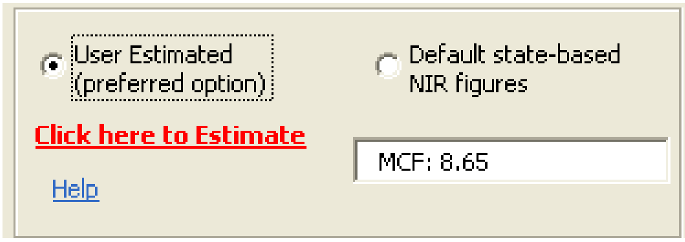


Figure 12. Click on the link Click to Calculate Manure Management Factor to access the milker and other stock classes' questions to estimate the manure methane conversion factor (MCF). Note the textbox with "MCF: 8.65" does not need data entered here, it is just there to show that the MCF has been calculated.

The questions are set out in a logical flow and if a question is not relevant, the questions will remain hidden so that the User will not see any irrelevant questions. For example, if the heifers and bulls do not spend any time on a feedpad area, it is assumed that 100% of their waste is spread daily during grazing and so no further questions are required. If, however, they do spend time on a feedpad area, questions will become visible.

Question 1 ascertains the amount of time per annum that the milkers spend on concreted areas where manure is deposited and flushed with additional water. For seasonal calving herds, the number of days will be the average lactation length. For year-round calving herds, it will still be the average lactation length, as opposed to 365 days, because it is determining the amount of time spent per individual cow, as opposed to the whole milking herd being present at the dairy.

Question 2 ascertains the number of hours per day the milkers are on this concreted area where manure is flushed with additional water. If the milkers are in the dairy or adjacent yards the whole duration of milking (i.e. not released until the last cows are milked), the number of hours will be the total time spent at the dairy. However, if the cows are allowed to leave the dairy and return to the paddock straight after milking, then it is the midpoint of milking time. For example, 1st cows begin to return after 15 minutes but last cows don't begin to return to the paddocks until 1hr 15 mins, the average time spent at the dairy is the midpoint of this at 45 minutes. *Note that time spent at the dairy uses decimal points, so 45 minutes per milking with 2 milkings per day would be 1.5 hrs, not 90 minutes. Also note that it is the average hours per day, not the peak duration, that we are concerned about, especially for seasonal calving herds that take longer to*

milk during the peak flow of milk production compared to when the herd is close to drying off for the season.

If the milkers leave the dairy but go to a feedpad area where any manure deposited is also flushed with additional water, this time needs to be added onto the time spent at the dairy as the manure is being handled in the same manner as if it was deposited in the dairy. Similarly, for total mixed ration farms where the milkers leave the dairy but return to their allocated pens and still have their manure flushed with additional water, the time spent in this system would be 24 hrs per day, for 365 days (if housed while also during their dry phase).

Question 3 ascertains how this flushed manure is handled, giving the user two options: spread daily from a sump or stored in a pond/lagoon system. The User determines the percentage of waste that is spread daily (either via a manure cart, a single nozzled irrigator or diluted in irrigation water or any other example) and the balance is assumed to be stored in the pond/lagoon system. If the User ascertains that all waste is spread daily, then DGAS determines that no waste is stored in a pond/lagoon system and so row 6 and Question 4 will be hidden. *Note that the percentage stored in the pond/lagoon system in row 6 does not need filling in; it is calculated based on Question 3. The equation in cell C6 is not protected, so if the User inadvertently types in this cell, the equations is lost and the User will need to manually determine how much is destined to the pond/lagoon system as opposed to spread daily.*

Question 3 is not referring to the frequency that waste is spread from the pond/lagoon system, only the proportion of annual waste that goes to the pond/lagoon system. Waste going to the pond/lagoon system (whether it is a single or double pond system) contains water, urine and manure. The water and urine will mix together and remain at the top of the pond and are then irrigated onto paddocks as required to empty the fluid component of the pond or to supply water to pastures and crops. The manure, however, generally settles to the bottom of the pond, remains anaerobic and continues to release CH_4 via methanogenic microbes until the solids are applied to paddocks. The time that the solids spend in the pond can be as long as 1-3 years depending on the size of the ponds and the amount of waste flushed into them.

Question 4 ascertains if the waste destined to the pond/lagoon system is pre-treated before entering the system. Is there a solids trap in place to capture a proportion of the solids from progressing to the pond/lagoon? For partial or total mixed ration farms, is there some form of mechanical separator (e.g. screw press or roller press) that removes a proportion of the solids from entering the lagoons? If there is no form of pre-treatment in place, the User must select “No” from the drop-down list in cell C7. However, if there is some form of pre-treatment, the User must select “Yes”, with an automatic 20% of the waste destined to the lagoon now considered to be solid storage waste as opposed to lagoon waste.

Question 5 ascertains if the milkers spend any time on a feedpad or loafing area where manure is deposited and periodically scrapped. If the milkers spend zero time on a feedpad, the User must select “No” in the drop-down list in Cell C11 and then the balance of the questions will be hidden. However, if the milkers spend some time on a feedpad area, Questions 6 and 7 appear and ask how many days per year and hours per day the milkers spend on the feedpad.

This feedpad manure is then handled in Question 8 as a dropdown list in cell C14 as either “Manure scrapped while wet (weekly or more frequently)” or “Manure dried and periodically scrapped (fortnightly or longer)”. Waste that is scrapped while wet into stockpiles is considered to be of solid storage consistency and therefore more conducive to anaerobic conditions and associated CH_4 emissions. Waste that is allowed to dry out before being scrapped into stockpiles is considered to be of dry lot consistency, with lower anaerobic conditions and associated CH_4 emissions. Solid storage MCF is higher than dry lot, at 4.0% compared to 1.5% for temperature regions, so there will be differences in the CH4 emissions depending on the classification of this scrapped waste. In addition, the emission factors for N_2O emissions from volatilisation for these two systems is also different, with solids storage at 0.3% compared to 0.2% form dry lot. If the scrapped manure is handled both ways depending on the time of year, volume deposited etc, Users should opt to classify this as solid storage as opposed to dry lot.

If the milkers spend more than 24 hrs in the dairy or on the feedpad, an error message will appear in Cell C15 as **Recheck hrs entered for dairy and feedpad as greater than 24**.

Similarly, milkers can only spend up to 365 days in the dairy and on the feedpad, otherwise an error message will appear telling the User to check the data entry. One the User has entered the baseline data entry and the % of waste to each manure management system is calculated and appears to be within the expected ranges (DGAS can't ascertain this, it is up to the User to gauge if the figures appear to be within the expected range), the % of waste to paddocks while grazing is calculated as the difference between 100% and the sum of all other systems (Figure 13.). The % of waste to paddocks while grazing also includes any manure deposited in laneways on the way to/from the dairy where the waste is not handled by either flushing and/or scrapping into stockpiles.

Manure methane conversion factor (%)	8.65
% waste to paddocks while grazing	90.6
% waste to daily spread	0.0
% waste to lagoon (untreated)	8.6
% lagoon waste separated to solid storage	0.0
% feedpad waste to dry lot	0.0
% feedpad waste to solid storage	0.9
TOTAL WASTE	100.0

Figure 13. Example of cells E3:F15 on the Milker Manure sheet showing that for this farm, 90.6% of waste was voided onto pastures during grazing, the waste deposited in the dairy went to the lagoon and equated to 8.6% of the milker annual waste. In addition, 0.9% of manure was deposited on a feedpad and was scrapped while wet into a solid storage stockpile. This manure management scenario resulted in a manure methane conversion factor of 8.65%.

The User then clicks on the **Click to copy baseline data to strategy** button to transfer the baseline milker data to the strategy milker data. For most farms, the baseline and strategy farm data will be the same. However, exploring changes to this aspect of the farm may be a viable strategy to explore. For example, what is the impact of feeding silage or hay in the paddock, as opposed to having a feedpad area to feed out these supplements, on the total farm GHG emissions? If the dairy was able to turn out the milkers in 2 hrs per day as opposed to 3 hrs per day, and therefore get them back

onto paddocks sooner, what is the impact of this on farm GHG emissions? What is the impact of going from a partial mixed ration to a total mixed ration farm?

Once the baseline and strategy milker data is entered, the only option available to the User is to click on the **Click to progress to baseline other stock classes data page** to progress to the other stock class data entry page. For the other stock classes, the heifers and bulls are grouped together for ease of DGAS calculations. Generally speaking, given the low number of bulls present on a dairy farm, this section is only referring to the heifers and it assumes the heifers < 1 yr old and heifers > 1 yr old are treated the same. However, if the heifers < 1 yr old spend time on the feedpad but the heifers > 1 yr old do not, then the time spent for the heifers needs to be halved. For example, if the heifers < 1 yr old spend 90 days and 2 hrs per day on the feedpad, this equates to approximately 2% of their time. But the heifers > 1 yr old spent zero time there, so the overall average would be that all heifers spend 1% of their time on the feedpad by either changing 90 days to 45 days or 2 hrs to 1 hr but not both options.

Question 1 for the other stock classes ascertains if these heifers spend any time on a feedpad area. If the answer “No” is selected in Cell C3, there is no additional questions shown, 100% of their waste is allocated to being voided onto pastures during grazing and the User can progress to the strategy section, by copying the baseline data across and then returning to the Farm Inputs sheet. *Note: Given the low volume of manure excreted during the pre-weaning stage for calves, we are only referring to the period after weaning when the heifers are generally out on pastures year-round.*

However, if the heifers do spend some time on a feedpad area, especially for the total mixed ration farms, then the number of days and hours per day needs to be entered in Questions 2 and 3. Question 4 then asks if the waste is flushed with additional water If this is yes, select “Yes” from the dropdown list in Cell C6, estimate the percentage spread daily as opposed to destined to the pond/lagoon system and if destined to the pond/lagoon system, indicate if the waste is pre-treated or not with the dropdown list in cell C9.

However, if the replacements spend time on the feedpad with the waste not destined to being spread daily and/or the pond/lagoon, the User is asked in Question 7 if the waste is allowed to dry out before being scrapped and stockpiled. If the answer to this question is Yes, select "Yes" from the dropdown list in cell C10. This will automatically indicate that the waste is dry lot and therefore excluded from being scrapped while wet. However, if the answer to Question 7 is "No", then DGAS automatically selects the waste as being scrapped while wet and stockpiled.

Once the baseline other stock class data is entered, select the Click to copy baseline data to strategy button, alter the strategy data if this is the strategy you are examining, click on the **Return to Farm Inputs** button and continue filling out the Baseline Farm Inputs data.
Error messages are also written in so that if the milking herd spend more than 24 hrs per day in the day and on the feedpad, this error message appears.

Recheck hrs entered for dairy & feedpad as greater than 24

In addition, if the sum of all the waste is less than or greater than 100%, due to incorrect data entry, this error message appears.

Check data entry as waste not equal to 100%

If either occurs, data entry needs to be checked and corrected.

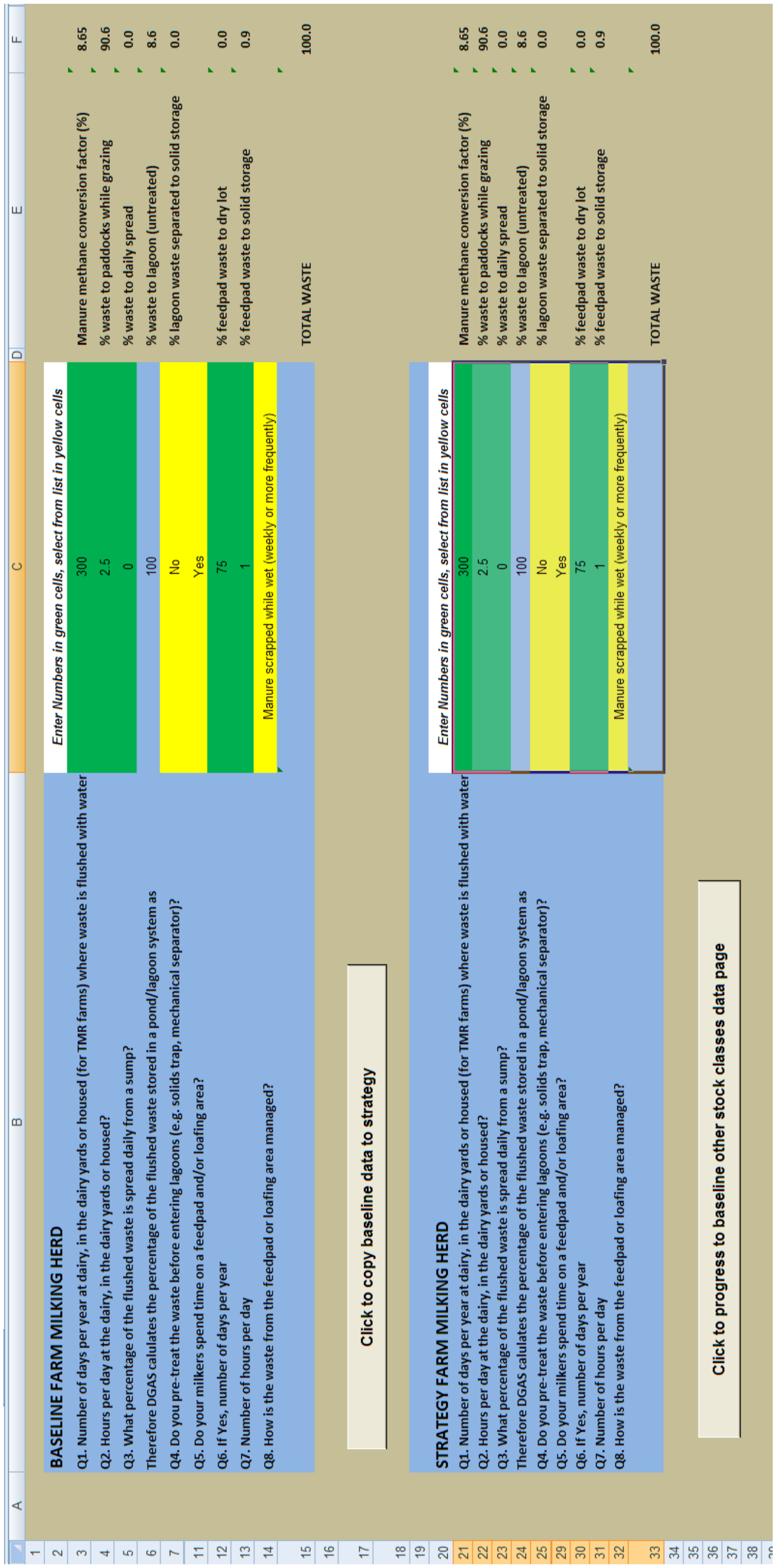


Figure 14. Example of the baseline and strategy farm Milker Manure spreadsheet.

Trees

The potential rate of carbon sequestration can be calculated based on the area of land planted to plantation after 1990, the dominant species and the average rainfall range selected. The amount of sequestration is shown in the bar graphs as a positive number for ease of graphing the results only. The total amount sequestered It is deducted from the total farm GHG emissions. Total farm emissions (sum of all sources) intensity is the net GHG emissions (total emissions minus carbon sequestered) divided by milk production. On-farm emissions intensity (CH_4 and N_2O only) is the sum of CH_4 and N_2O emissions divided by milk production without the impact of the sequestration taken into consideration. ***Note, if farmland is taken out of production for tree plantings, the User needs to manually deduct farm land from either irrigated or dryland pastures or crops; DGAS can not know where this land has come from. This is especially important if the fertiliser rates are based on kg/ha as opposed to tonnes/annum as less fertiliser is applied.***

Farmland area

This section allows the User to indicate the area of farm that is considered as growing irrigated and dryland pastures and crops, with the calculator determining total area. Total farm area includes the milking platform plus any area used to raise replacements, maintain dry cows and/or grow supplementary feed for the farm. The accuracy of this section is very important when selecting the fertiliser kg/ha option (see next section). However, total farm area is also important for future analysis so accuracy is desirable.

Fertiliser inputs

The fertiliser inputs section is important to record the amount of nitrogen fertiliser applied to determine nitrous oxide emissions associated with the fertiliser and to determine pre-farm GHG emissions associated with all fertiliser inputs. The User has one of two options when entering fertiliser inputs. The first fertiliser input option is kilograms per hectare (kg/ha; shown in Figure 15.). When this option is selected, the amount of nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) applied to each of the four classes (irrigated and dryland pasture and crops) is multiplied by the area of each class to determine the total amount of fertiliser applied. If this option is employed, accurate farmland area is important. Under some circumstances, farmland area may need to be greater than the actual farm area. For example, a 10ha irrigated crop from spring

through to autumn seasons may have had 100kg N/ha applied over the growing period. After harvesting, this area may be oversown with a dryland perennial pasture for winter and fertilised with 155 kg N/ha. This fertiliser inputs option will cater for these different classes and fertiliser rates.

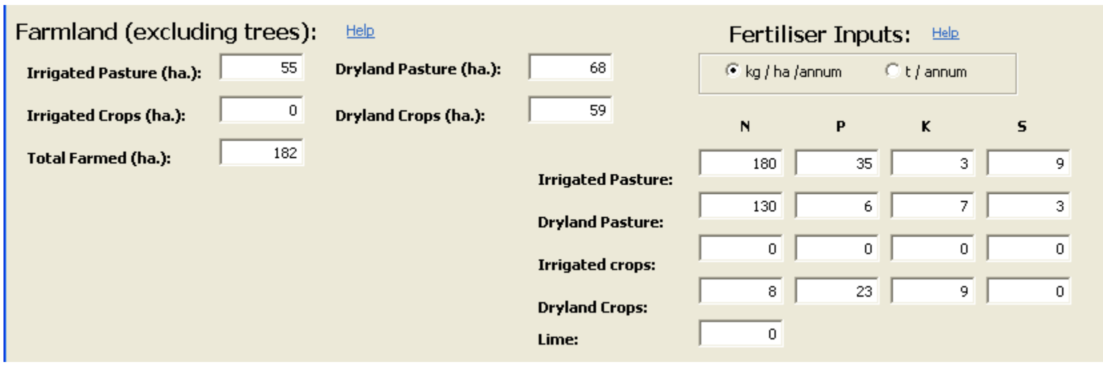


Figure 15. The fertiliser inputs section, highlighting that kilograms of element per hectare per annum option was chosen and that there was fertiliser applied to irrigated and dryland pastures and to dryland crops.

The second fertiliser input option is tonnes per annum (tonnes of nutrient /annum). Selecting this option is used when a total amount of nutrient is known, but unlike the first option, this option isn't linked to the farmland area. If the User is unsure as to whether the fertiliser was applied to irrigated or dryland pastures/crops (i.e. just know that you purchased 100t N but unsure how much of it went onto irrigated pastures/crops and how much went onto dryland pastures/crops), just enter the information in the corresponding irrigated boxes. The overall emissions will only be marginally greater using the irrigated option compared to the dryland option. The help button will assist the User with calculating fertiliser inputs.

Farm inputs

There are three types of electricity source that can be selected; coal, natural gas and clean (hydro, wind, solar etc). As most of Australia is linked to a national grid, it may be difficult to know what the source of electricity is. To overcome this, there is a 4th option, unknown, which can be selected. While most farms fuel usage would be predominantly diesel, if larger amounts of unleaded fuel is used, this can be included in the diesel usage. The GHG emission factors for diesel and unleaded fuel are similar so the outcome would be accurate.

Purchased feed inputs

The User can enter the amount of purchased feed inputs brought onto the farm. There are four forages, a grain/concentrate and a by-product section. These figures are reported as tonnes of dry matter per annum and are multiplied by an emission factor to determine the GHG emissions associated with the production of these feed types. By-products include feeds like canola meal, whole cottonseed, vegetable waste, brewers' grain etc. Select the section that is most appropriate to the feed types you purchase but do not be too concerned as these amounts are only important for the pre-farm GHG emissions calculations.

Herd Inputs

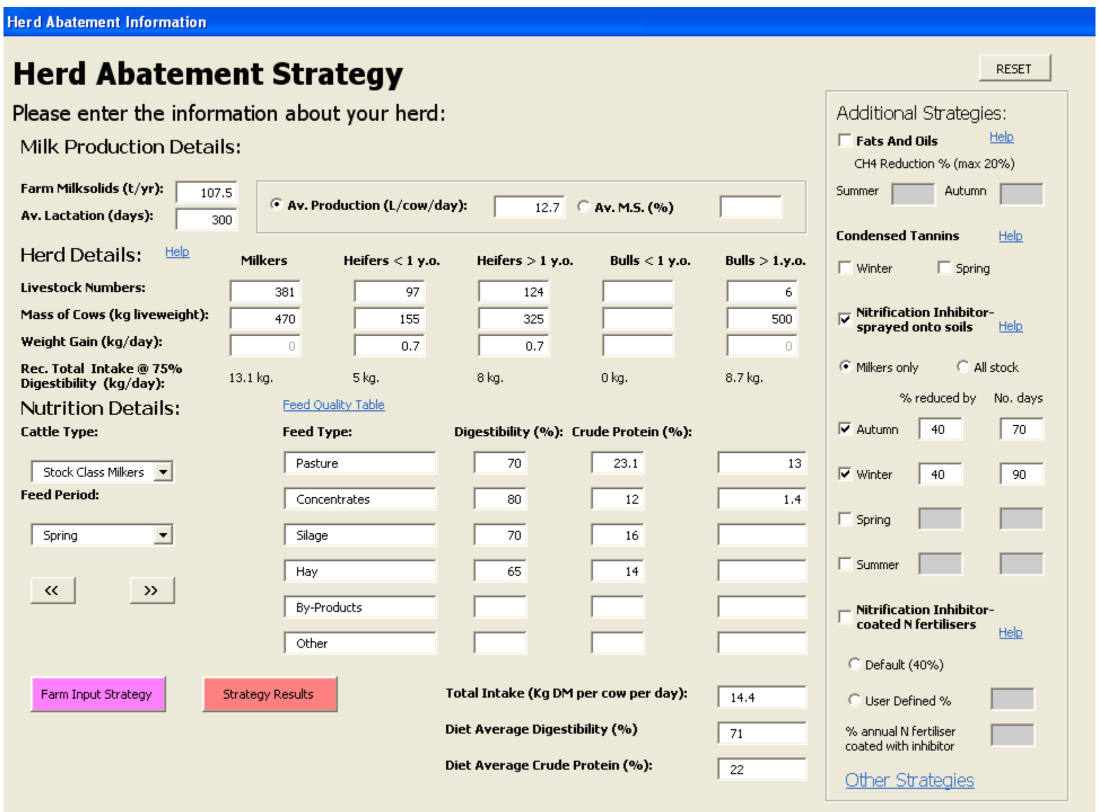


Figure 16. The Herd and Herd Abatement Strategy pages are identical with the exception of the additional strategies section and the colour of the navigation buttons. This allows for the inclusion of four fixed greenhouse gas abatement strategies: feeding fats and/or tannins and using a nitrification inhibitor either as a spray onto pastures after grazing or as a coating on nitrogen fertilisers. These strategies can be used in isolation or in combination by checking the appropriate boxes and filling in the relevant information.

Milk production

Milk production details are needed to determine the level of energy from the diet that is available for methane production. Daily per cow milk production can be calculated by one of two methods. If daily per cow milk production is known, click on the Av. Production (L/cow/day) radio button and enter the litres. This figure is the average litres per day for the whole duration of the lactation, not the peak milk production. For example, if the average per cow milk production was 6,000 litres over 300 days, then production per day would be 20 litres. The above example (Figure 16.) uses this option, with each cow producing an average of 12.7 litres/day over the duration of their lactation. The second option is by clicking on the Av. MS (%) radio button and entering the average milksolids percentage over the duration of the season. When using this second option farm milksolids, average lactation length and number of milkers need to be already entered. If any of these figures has not been entered prior to selecting the Av. MS button, an error message will prompt the User to this. If using the Av. MS (%) radio button option, the calculator determines and reports the daily mean milk production for each cow in the Av. Production (L/cow/day) box. This gives the User an opportunity to review the various values if this milk production figure seems too high or low.

Herd details

There are five herd categories- one for the milking herd, two for replacements and two for bulls. The User needs to enter herd size and weight of the milking herd. If you are milking year round, enter the total number of cows that would have calved in the 12 month period and contributed to the total milk production. For example, if you milk 300 year round, with approximately 30 calving each month then the total number of cows would be 360. Enter the number of heifers less than 1 yr old, their weight at 6 months of age (approximately 35% of mature cow weights) and liveweight gain (usually 0.6.- 0.8 kg/day), heifers greater than 1 yr old, their weight (approximately 75% of mature cow weight) at 18 months of age and liveweight gain (usually 0.6 - 0.8 kg/day), bulls less than 1 yr old, weight and liveweight gain (similar to heifers less than 1 yr old) and bulls greater than 1 yr old which is the category for mature bulls. Some farms may only have bulls present during the mating season, so if the farm has 8 bulls for a 3 month period, this equates to having 2 bulls per annum.

Calculation of feed intake

The User needs to enter seasonal diet quality for the milking herd and annual diet quality for the replacements and bulls. When the *Herd Information* form is opened, the cattle type will be Milkers and the feed period will be Spring (Figure 17.). Then click on the right navigation button below the feed period to move into summer, autumn and winter for the milking herd, followed by annual diet for Heifers <1 year old., Heifers >1 year old, Bulls < 1 year old and Bulls >1 year old. The User can also navigate backwards by using the left navigation button or can navigate right through the sequence back to the section required.

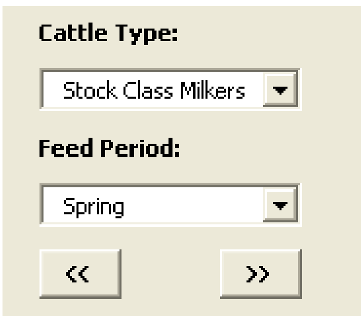


Figure 17. The navigation buttons allow to sequence through the cattle type and feed period for the various stock classes and seasons.

Five specific feed types are considered and a sixth category can be used to incorporate “Other” feed types. If you are feeding two types of silage but no hay, the second silage figures can be entered in the hay section to determine the diets’ digestibility and crude protein %.

The calculator has been programmed to automatically suggest likely dry matter digestibility and crude protein % for pasture, concentrates, silage and hay. While these figures are typical, the User may wish to alter these figures on the *Herd Inputs* form. If however, the User wants a more permanent change of the default figures, by clicking on any of the EXCEL buttons (assessed from the *Farm inputs* or *Results* forms), selecting the HerdSheet worksheet and scrolling down to cell A24 (Figure 18.), each of the feed types can be altered. Save this new version of DGAS with a new name, then open up and reset both the *Herd Information and Herd Abatement Strategy* forms. Save this new version again so that each time the calculator is opened, these altered values appear for each stock class.

Default Feed Values.	
Pasture	
Digest.	70
Protein	20
Concentrate	
Digest.	80
Protein	12
Silage	
Digest.	70
Protein	16
Hay	
Digest.	65
Protein	14

Figure 18. Default feed values for digestibility and crude protein for pastures, concentrates, silage and hay for all stock classes.

All feed data needs to be entered on a dry matter basis, by converting all wet weights to dry weights. For example, grain is generally 90% dry and 10% moisture. If you feed 5 kg of grain (as fed), multiply this by 90% to get 4.5 kg DM. Likewise, if you feed 3 kg of silage (as fed) that is 33% dry, then by multiplying 3 kg by 33%, you are feeding 1 kg DM of silage. Average dry matter %, dry matter digestibility % and crude protein % for an array of feed sources can be accessed by clicking on the Feed Quality Table button. This takes you to a list of common feed sources, sourced from a Victorian DPI website. To return to the *Herd Inputs* form, click on the close button in the top left hand corner.

Entering the daily intake of each feed source with their corresponding digestibility and crude protein % is essential to determine the seasonal diet quality figures for the milking herd or annual diet quality for all other stock classes. While these figures need to be fairly accurate, there is some room for variation. Therefore do not be too concerned if you are not sure if its 8 or 9 kg DM pasture/day, as long as the figures are relatively accurate. These intake values determine the overall dry matter digestibility and crude protein figures and are used to determine methane and nitrous oxide emissions.

The User may decide to enter the same digestibility, crude protein and quantity for each feed type for each season or may enter varying figures for each season to replicate the

changes in diet expected over the lactation. This second option is preferable when assessing season abatement strategies such as feeding fats and oils.

A recommended daily feed intake is estimated for the milking herd to achieve their daily milk production average, based on the overall diet having a digestibility of 75%. This figure is intended as a convenience for the User, so that once the User has entered the milk production data and the amount of grain and other supplements, they can then have a realistic indication of the daily pasture intake required to achieve that level of milk production. The recommended daily intake can also assist if one abatement strategy involves an increase in milk production. The User is able to ascertain the level of feed intake required to achieve this increase in milk production and therefore increase feed intakes accordingly. The feed intake calculation assumes an average feed digestibility of 75% and will not be shown until milk production and herd weight are entered. For the example below (Figure 19.), the herd would need to be consuming a minimum of 13.1 kg DM/day over the duration of the lactation to achieve the milk production entered. Likewise the heifers would be required to consume approximately 5 and 8 kg DM/day to achieve their desired weight and liveweight gain, while the mature bulls would require approximately 8.7 kg DM/day.

Herd Details: Help	Milkers	Heifers < 1 y.o.	Heifers > 1 y.o.	Bulls < 1 y.o.	Bulls > 1.y.o.
Livestock Numbers:	381	97	124		6
Mass of Cows (kg liveweight):	470	155	325		500
Weight Gain (kg/day):	0	0.7	0.7		0
Rec. Total Intake @ 75% Digestibility (kg/day):	13.1 kg.	5 kg.	8 kg.	0 kg.	8.7 kg.

Figure 19. The daily feed intake to achieve this level of milk production is 14.33 kg DM/day over the duration of the lactation, when the diet is 75% digestible. If the mean digestibility is lower, this intake needs to be slightly higher.

When the user scrolls through each season for the milking herd or annual for all other stock classes and enters the diet intake figures, DGAS checks this against the predicted daily intake. If the entered intake is substantially different to the DGAS predicted intake (based on milk production, liveweight and liveweight gain), an error message will appear suggesting to check diet intakes (Figure 20).

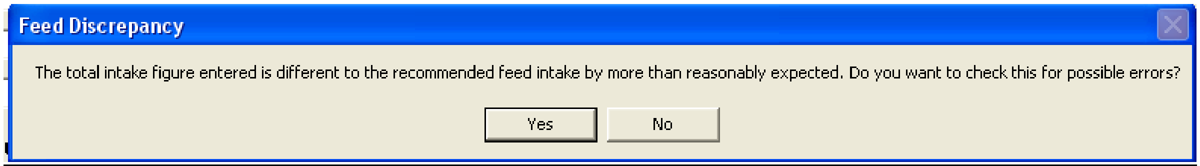


Figure 20. Feed discrepancy help message suggesting that diet intakes are outside a reasonable acceptable range for the stock class just entered.

If the user does not fill the diet intakes for each of the four seasons for the milking herd, or does not fill in the annual diet intakes for all other stock classes when stock have been entered in the herd details section, once the user selects the results button, an error message will appear indicating which diet intakes need entering (Figure 21.).

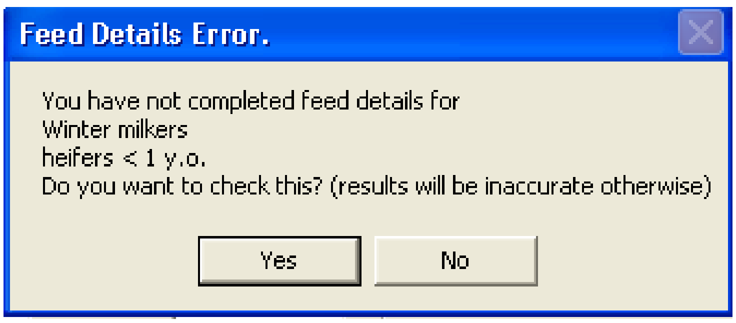
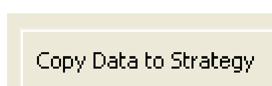


Figure 21. Feed details error message indicating that the winter diet for the milkers and the heifers < 1 year old diet has not been completed.

<u>Copy baseline data</u>

Once farm and herd data is entered on their corresponding forms, all entered data can be transferred to their corresponding abatement forms. This is achieved by clicking on the "Copy Data to Strategy" button 

at the bottom left hand side of the page. This reduces the re-entry of the same data needed on the abatement strategy pages. When the User navigates to the strategy forms, they need only edit the particular inputs they wish to change.

Economics

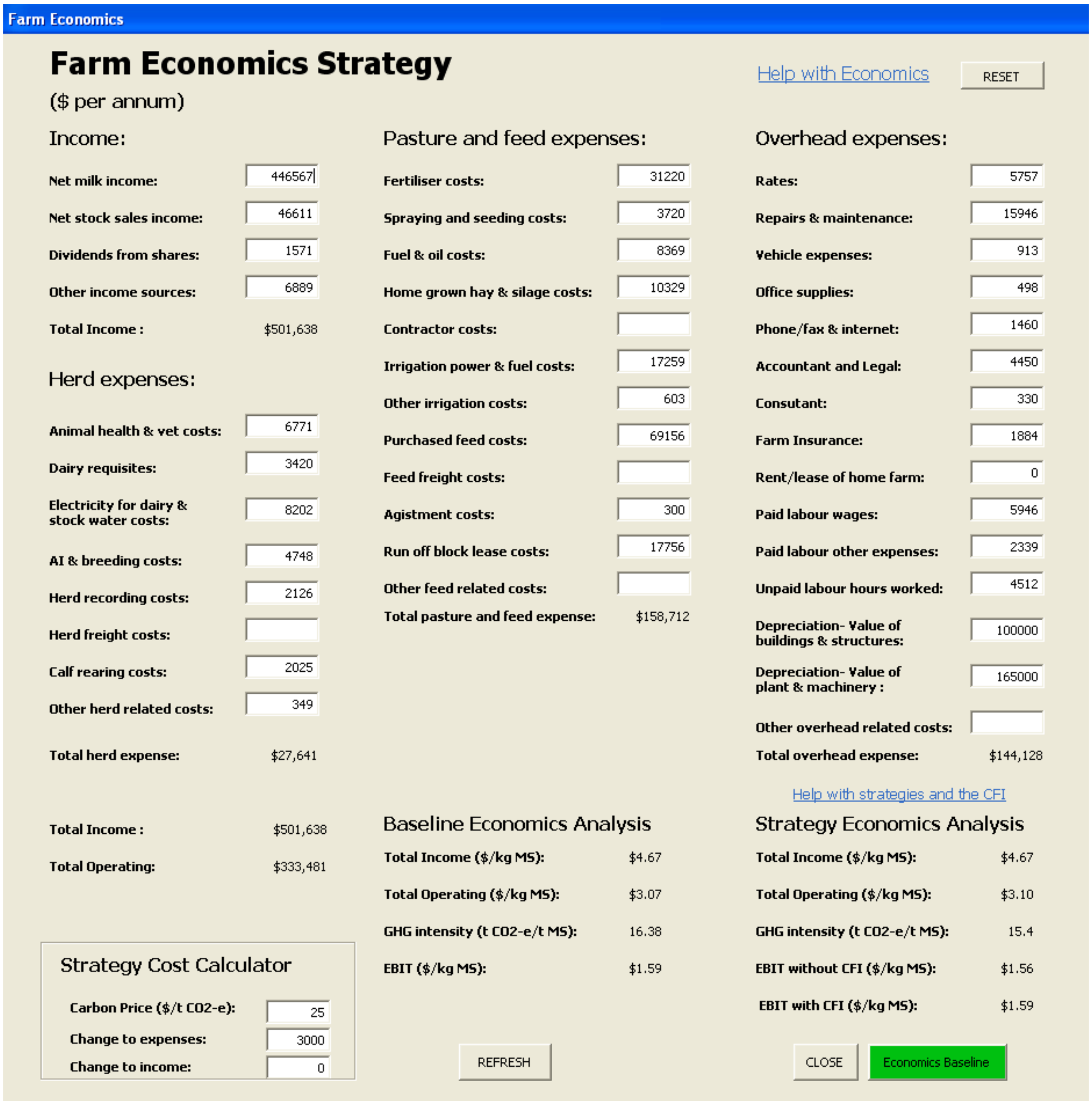


Figure 22. The Farm Economics Baseline and Farm Economics Strategy (page shown) are identical, with the exceptions of page headings, the Strategy Cost Calculator section and the Strategy Economics Analysis section are hidden and the navigation button between the Baseline and Strategy sheets changes colour and heading.

DGAS version 1.2 contained an economics section to be filled out to assess the impacts of an emissions trading scheme and/or adopting abatement strategies on farm profit. Given that the government policy on the role of agriculture has altered significantly since the release of the previous version of DGAS, we have reconfigured the economics pages for version 1.3 (Figure 22.). The current policy (commencing July 2012) on the

role that agriculture could play has changed with the introduction of the Carbon Farming Initiative (CFI). Farmers now may have the ability to gain payment for abatement strategies that meet all the stringent requirements of the CFI. These include additionality, permanence, avoidance of leakage, measureable and verifiable, scientifically sound and meets international consistency. At the timing of this DGAS release, none of the current abatement strategies activated within DGAS meet all these requirements. There will also be additional costs to farmers to achieve any income benefit through the CFI in areas such as greater time spent meeting the requirements needed on-farm to meet methodology. Therefore the economics page should still be used with a high degree of caution when reporting to farmers the economic benefits of adopting abatement strategies, especially in light of carbon policies.

If an abatement strategy is activated, the user needs to decide the impact of this strategy on other aspects of the farm (see the Additional Abatement Strategies section for more information). The user also needs to ascertain any changes to expenses and income as a result of the abatement strategy. For example, the nitrification inhibitor coated fertiliser costs an additional \$5000 compared to the standard non nitrification inhibitor coated fertiliser cost for the baseline farm. Any changes to expenses and income are recorded in the Strategy Cost Calculator section. In addition, the carbon price (\$/t CO2) is included in this section.

The Baseline Economics Analysis EBIT is the difference between income and operating expenses divided by milk production (kg MS/annum). There are two Strategy Economics Analysis EBITs. The 1st one is EBIT without CFI. This is similar to the baseline EBIT in that is it the difference between the new income and new expenses divided by milk production. The 2nd is EBIT with CFI and this takes into consideration an income generated by implementing an abatement strategy that qualifies for CFI payment and therefore improving the EBIT compared to the EBIT without CFI.

For example, in Figure 22 above, the baseline farm EBIT was \$1.59/kg MS and the on-farm CH_4 and N_2O emissions intensity was 16.38 t CO_2e/t MS. The adoption of an abatement strategy (in this case a spray nitrification inhibitor in autumn and winter) cost \$3000, therefore resulting in a new strategy EBIT without CFI of \$1.56/kg MS. After adopting a strategy, the on-farm CH_4 and N_2O emissions intensity was reduced to 15.40

t CO_2e/t MS. This strategy qualified for inclusion in the CFI and the price for carbon at the time was $25/t CO_2e. By multiplying the reduction in GHG emissions by the carbon price, this strategy ‘paid’ an extra $0.03/kg MS, resulting in a new EBIT with CFI of $1.59/kg MS; similar to the baseline farm EBIT before any abatement strategy was considered.

Results

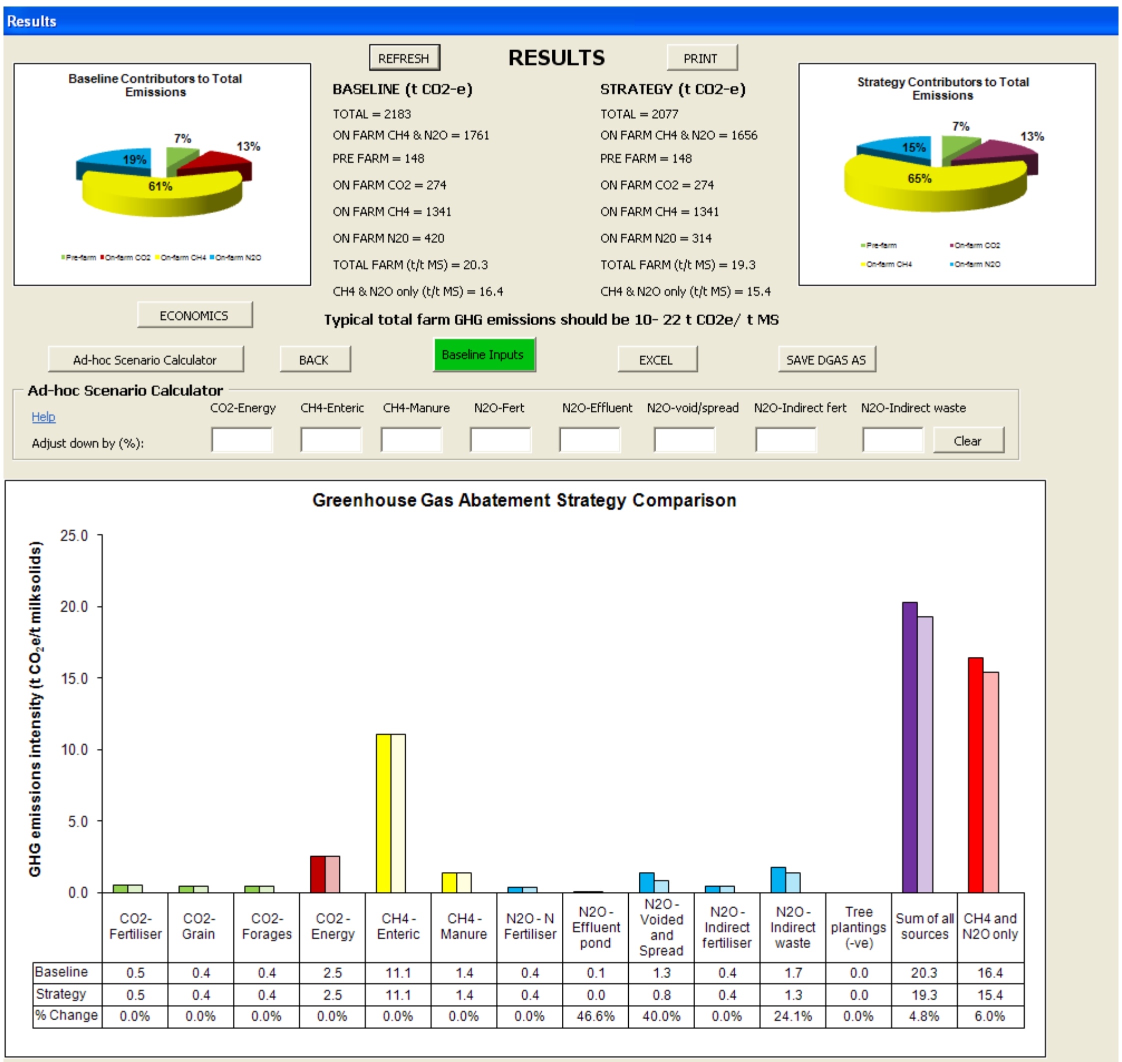


Figure 23. The results form shows the comparison of baseline and strategy greenhouse gas emissions. A summary of these results together with the farm and herd data can be printed from this *Results* form by selecting the Print button at the top of the *Results* form. The Ad-hoc calculator section can be hidden/unhidden by selecting the Ad-hoc Scenario calculator button just above the calculator.

The graphs shown on the *Results* form are images copied from the ResultsSheet in the workbook (Figure 23.). Each time you make a change and return to the *Results* form, this image is updated. A refresh button is provided so that you can re-assure yourself that you are looking at the most up-to-date results from the calculator. If there appears to be an error in the data entry, the User can either scroll forwards through the forms by selecting the **green** Baseline Inputs navigation button if the error is in the baseline data or select the back navigation button if the error appears in the abatement strategy data.

Pie chart

The Pie charts (one for the baseline and one for the strategy) show the proportional contributions of the pre-farm embedded emissions and the three on-farm gases associated with the enterprise.

Absolute values list

The absolute tonnes of greenhouse gases for the farm (as CO_2 equivalents) are listed in two tables between the pie charts. In addition there is a repeat baseline and abatement strategy total farm GHG emissions/t MS and the CH_4 & N_2O only GHG emissions/t MS from the column graph. Total farm GHG emissions (inc. pre-farm and on-farm CO_2) would be expected to be in the range of 10-22 t CO_2-e/t MS. Any figures substantially different to this could be due to incorrect data entry.

Column graph

The column graph shows the contributing factors and total emissions for the baseline farm (solids columns on the left hand side of each set of 2) and the abatement strategy farm (hashed/ faded columns on the right hand side of each set of 2). The column and pie chart colours are similar, so the yellow section in the pie chart (CH_4) is the same as the yellow columns (CH_4-enteric and CH_4- effluent ponds). The units of measurement are tonnes of carbon dioxide (CO_2) equivalent per tonne of milksolids produced.

The contribution of tree plantings in sequestering CO_2 is subtracted from the total emissions from the farm, but is shown on the graph as being a positive value. This is only for formatting reasons and has been identified on the axis label as “Tree Plantings (-ve)”.

The last two sets of columns on the right hand side of the graph represent total farm emissions and the on-farm CH_4 & N_2O only emissions for the baseline and strategy farm. Total farm emission is the sum of pre-farm embedded emissions, on-farm carbon dioxide emissions, on-farm methane emissions and on-farm nitrous oxide emissions minus any tree planting sequestration.

The data table below the column graph indicates the actual values of each contributor and the percentage change in emissions achieved by adopting an abatement strategy for each contributor. A positive ‘% change’ figure indicates that the GHG emissions/t MS for that source has decreased while a negative ‘%change’ figure indicates that the GHG emissions/t MS for that source has increased (e.g. increased grain feeding could result in a negative % change figure).

Ad-hoc strategy calculator

The Ad-hoc calculator can be hidden/unhidden as required by selecting the Ad-hoc scenario calculator button located just above the calculator. The User is able to enter values for a single strategy that is not included in the calculator (Figure 24.). The ad-hoc strategy allows for the User to define a percentage reduction in emission from the seven sources of GHG emissions. This can be used to provide an indication of the level of reduction in emissions required to meet a farm emission target. The User should enter a percentage for each type of emission affected by the strategy. Help is provided to assist with use of the ad-hoc strategy calculator. The strategy series on the graphs and absolute value lists change to reflect the new strategy, when the User moves to a new field or uses the tab key. Ad-hoc scenarios are only retained for the session. They are removed when the workbook is next opened. For the below example, the User has determined a strategy that reduces CO_2 emissions by 10% and a strategy that reduces CH_4- Enteric emissions by 15%. The calculator would then work out the new total farm and ETS emissions for this strategy.

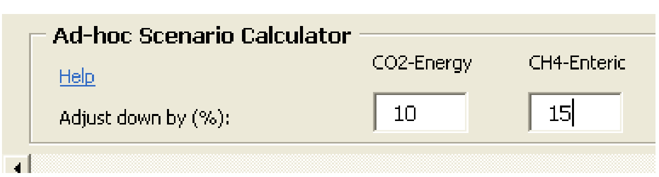


Figure 24. The Ad-hoc Scenario Calculator allows the User to alter DGAS’s strategy output.

Additional Abatement Strategies

Four additional abatement strategies have been included on the *Herd Information Abatement Strategy* form. The User can select to feed Fats and Oils, feed Tannins and/or use a Nitrification Inhibitor, either as a spray onto pastures directly after grazing or as a coating on nitrogen fertilisers, to reduce emissions. The strategy of reducing emissions by feeding fats and/or tannins is only operational on the milking herd; we have not programmed DGAS to calculate the effects of these two strategies for the replacements and bulls. The four approaches can be used concurrently (Figure 25.). However, the additionality of these abatement strategies is still questionable and users are recommended to seek additional expertise before assuming that abatement strategies are comparative with each other and lead to cumulative reductions.

DGAS does not assess other impacts of these abatement strategies on the whole farm system. For example, if a nitrification inhibitor resulted in greater pasture production over winter, due to a greater N being available for plant uptake as opposed to leaching, what role does that extra feed play? Can supplementary feeding be reduced? Can extra cows be milked? Another example is feeding fats and oils whereby the User needs to add this additional feed source to the diet quality calculations on the herd information page. Is the source of dietary fat additional to the baseline diet or does it replace a component of the baseline diet? Are there changes to the energy content of the diet and if yes, will this increase in energy in the diet result in increased milk production?

Therefore we suggest care is taken when assessing the impact of adopting abatement strategies on the whole farm system, not just the potential reduction in GHG emissions.

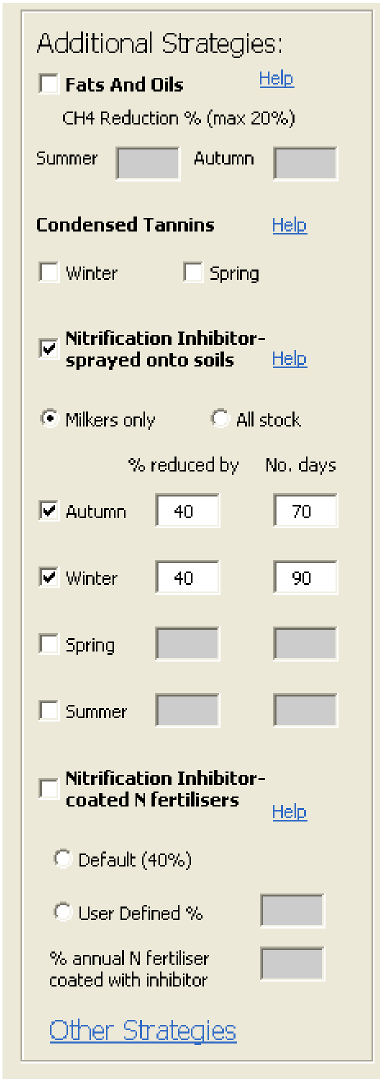


Figure 25. The four current additional abatement strategies that are available to be implemented are feeding fats and oils for summer and/or autumn, feeding tannins in winter and/or spring, using a spray nitrification inhibitor for any season and using a fertiliser coated nitrification inhibitor. Other strategies can be selected to assist in understanding how to use the Ad-hoc Scenario calculator. Help is available to assist with each of these.

Fats and oils supplementation

Feeding fats and oil can reduce enteric methane emissions. Only select this option if you know the fat content of the diet prior to the strategy being implemented. Cows can be fed fats to a maximum of 6-7% of their diet. All feeds contain fats so by calculating the fat content of the diet, you can determine if this abatement strategy is suitable for your farming system. For each 1% additional fat in the diet, there is potentially a 3.5%

reduction in methane. Therefore if your herd's current summer diet contains 3% fat, you could safely feed another 3%, with a 10.5% reduction in methane. Type 10.5 into the summer box and add the quantity and quality data of the fat into the summer nutritional details. Generally there is some scope to feed fats and oils over summer and autumn periods, especially under dryland conditions.

If this strategy is implemented, is the feed additional to the baseline diet or does it replace a component of the baseline diet? Has the diet changed sufficiently to later milk production? The dietary fat needs to be added manually to the diet quality matrix on the *Herd Abatement Strategy* form to recalculate the feed intake, digestibility and crude protein figures. Users also need to manually alter the milk production figures if the addition of the dietary fat does impact on milk production. Seek nutritional advice if you wish to adopt this abatement strategy, as feeding fats above 6-7% will decrease feed intakes and result in a depression in milk production.

When implementing this strategy, there are several other points that need considering and therefore require manual implementation in DGAS:

- Is the dietary fat a substitution for another feed source? or is it additional to the baseline diet?
- If the dietary fat is additional, does the higher energy content of the diet mean that the milkers can now consume more of the lower digested pasture that is available?
- Does the dietary fat change the seasonal diet mean digestibility and crude protein %?
- Does the dietary fat impact on milk production?
- Does the feeding of dietary fats result in a substitution effect with a reduction in pasture intakes?

Tannins supplementation

Feeding condensed tannins could assist in reducing GHG emissions by binding proteins in the diet so they are better digested. Feeding tannins is only a viable option if there is excess crude protein (> 18% CP) in the diet. As most Australian pastures, especially dryland pastures, only contain excess CP in winter and spring, we have reduced the availability of this strategy from year-round to winter and/or spring. For diets within the

optimal crude protein % range (i.e. 16-18%), this is not a viable abatement strategy. Therefore even if this strategy is activated in winter and/or spring, it will only activate if the diet for the activated period has a diet over 18% CP. For diets, ≤ 18% CP, the strategy will not be activated even if selected. For diets > 18% CP, the CP% of the diet will be reduced automatically to 18%, with a flow-on effect on animal waste N_2O emissions and the enteric CH_4 emissions will also be reduced by 10%. If a source of condensed tannin is fed, the user will need to consider any impact on diet quality and milk production and make the necessary changes to the diet quality matrix and milk production manually.

When implementing this strategy, there are several other points that need considering and therefore require manual implementation in DGAS:

- Is the source of condensed tannin a substitution for another feed source? or is it additional to the baseline diet?
- If it is substituting another source of feed, could that substituted feed be used to increase the stocking rate?
- Will the reduction in diet CP% result in less energy being used to excrete excess N in urine and therefore greater energy being available for milk production per cow?

Nitrification Inhibitor- sprays and nitrogen fertilisers

Nitrification inhibitors can reduce the emission of N_2O associated with animal waste (urine and dung patches and the application of manure from effluent ponds). The user can decide if the spray nitrification inhibitor is applied to the waste from the milking herd only or applied to all waste on farm by selecting the appropriate radio button. The user also needs to define which season the inhibitor is applied, the % reduction potential of the spray and the number of days the spray is effective in reducing N_2O emissions. If the user does tick one or more seasons, but does not fill in the % reduction potential of the inhibitor and/or the number of days the inhibitor is effective, DGAS assumes a 40% reduction for the whole season (i.e. 90 days in summer, 91 days in autumn and spring and 92 days in winter). Users also have to consider if the spray inhibitor will impact on reducing N_2O emissions from fertilisers also applied in the same timeframe. If yes, then the user needs to do this manually by activating the fertiliser inhibitor also for a % reduction in emissions on a proportion of the annual fertiliser applied.

Nitrification inhibitors can also reduce the N_2O emissions from the application of nitrogen fertilisers. Users can either select the default 40% reduction potential or select their own reduction potential. Users also need to identify what percentage of their annual N fertiliser is coated with the inhibitor and applied during times of the year when the inhibitor will be effective (i.e. generally autumn through until spring on free-draining soils when the risk of leaching N from the soil profile is greatest but could also be during summer on irrigated pastures). If the user selects that strategy, but does not indicate the percentage of N fertiliser that is coated with the inhibitor, DGAS assumes that all fertiliser is reduced by 40% on a per annum basis.

We strongly suggest that users fill in all relevant sections and do not rely on the default, in-built DGAS factors for predicting the reduction potential of nitrification inhibitors as these are likely to result in higher emission reductions than has been observed in research results. We also suggest users seek regional research project results to assist in developing the reduction potentials for these two strategies.

When implementing these two strategies, there are several other points that need considering and therefore require manual implementation in DGAS:

- Will the additional N available from animal waste and/or fertiliser applications result in additional pasture production?
- If yes, how will that additional pasture production be managed? Will other supplementary feeds be reduced? Will the extra pasture production result in additional milk production per cow and if yes, by how much? Will the extra pasture production be sufficient to milk additional cows?

<u>Where in DGAS are these abatement strategy calculations activated?</u>

a) Dietary fats - when the dietary fats strategy is selected in summer and/or autumn, and the percentage reduction in enteric CH_4 emissions are entered on the *Herd Abatement Strategy* form, the reductions are activated on the Enteric CH_4 sheet. The summer reduction occurs in cell D37 and the autumn reduction occurs in cell E37.
b) Condensed tannins - when condensed tannins strategy is selected in winter and/or spring on the *Herd Abatement Strategy* form, the 10% reduction in enteric CH_4 is activated on the Enteric CH_4 sheet in cells F37 (winter) and C37 (Spring).

If this strategy is activated but the diet CP% for the season is ≤ 18% CP, the enteric CH_4 emissions will not be reduced. If this strategy is activated, and the diet is > 18% CP, the 10% reduction in enteric CH_4 will be activated. The winter diet will be reduced to 18% CP in the equation on the N_2O Fecal sheet, cell G6 while for spring, the equation altered will be in cell D6 of the N_2O Fecal sheet.

c) Nitrification inhibitor (spray) - when the nitrification inhibitor (spray) strategy is selected on the *Herd Abatement Strategy* form, the user can either implement the strategy on the waste (dung, urine and manure) of the milking herd only or for all stock. The user has all four seasons when the strategy is potentially effective. The user has to define the % reduction potential and the number of days the spray is effective or allow the defaults in DGAS to be used. These defaults are 40% reduction for the whole season. The N content for dung and urine will be reduced on the N_2O Fecal sheet in cells D48:K48 and D50:K50. This will then also reduce the direct N_2O emissions from the manure. The sprays will reduce the indirect leached N_2O emissions but not the indirect volatilised N_2O emissions.

d) Nitrification inhibitor (fertiliser) - when the nitrification inhibitor (fertiliser) strategy is selected on the *Herd Abatement Strategy* form, the user can either use the default 40% reduction or select any other reduction %. Direct N_2O fertiliser emissions are reduced on the N_2O SoilsFert sheet, cells V31:V34 for irrigated pastures, irrigated crops, dryland pastures and dryland crops, respectively. Note that the reduction is across all these, it can't be isolated to just one or two options (e.g. irrigated crops only). For indirect N_2O emissions from fertilisers, the reduction in N_2O emissions occurs with selecting the new N_2O emissions in the N_2O SoilsFert sheet, cells N64 (for leaching/runoff). There is reduction in volatilised N2O emissions from fertilisers with this strategy.

Acknowledgements and Licensing

DGAS is funded by The Department of Agriculture, Fisheries and Forestry (DAFF), Dairy Australia (DA) and the University of Tasmania; compiled by staff of the Tasmanian Institute of Agricultural Research (Robert Kildare, Karen Christie and Dr Richard Rawnsley) with the assistance of Dr Richard Eckard, University of Melbourne.
This calculator is a further development of the Dairy Greenhouse Framework calculator, compiled by Richard Eckard, Roger Hegarty and Geoff Thomas.

Note: a) The calculator is subject to development at all times,

b) The methods are continually changing so we take no responsibility for the currency of the tool, and

c) Professional advice should be sought on the interpretation of the results and the consequences of adopting abatement strategies.

Appendix 1: DGAS Adviser calculator data inputs

Farm inputs

Farm identification: *State:*

Manure management system (milkers):

User Estimated Default state-based figures

Days per year & hours per day at the dairy, yards and/or housed

% of flushed waste is spread daily % of flushed waste to lagoon

(Note : sum of spread daily and lagoon waste must be equal to 100%)

Do you pre-treat lagoon waste (e.g. solids trap, mechanical separator)? (circle) YES NO

Do the milkers spend time on feedpad where waste is scrapped? (circle) YES NO

If Yes, days per year & hours per day

How is feedpad waste handled? (circle) Scrapped once dry (dry-lot; fortnightly or longer)

or Scrapped still wet (solid storage; daily to weekly)

Manure management system (heifers- figures are average for heifers < 1 & heifers > 1):

Do the heifers spend any time on a feedpad area (either flushed or scrapped)? YES NO

If Yes, days per year & hours per day

Is the manure either flushed and spread daily and/ or flushed to a lagoon? YES NO

If Yes, what % of flushed waste is spread daily? % to lagoon

If some waste goes to the lagoon, is it pre-treated? (circle) YES NO

For manure not flushed and spread daily or to the lagoon, is it (circle)?

Scrapped once dry (dry-lot) or Scrapped while still wet (solid storage)

Tree plantings after 1990 (ha): *Species:*

Total farm area: Irrigated pastures (ha) Dryland pastures (ha)

Irrigated crops (ha) Dryland crops (ha)

Fertiliser inputs (tick): kg/ha or tonnes/annum

Irrigated pasture (N:P:K:S)

Dryland pasture (N:P:K:S)

Irrigated crops (N:P:K:S)

Dryland crops (N:P:K:S)

Lime

Electricity (kWh): *Diesel (litres):*

Electricity source (coal, gas, hydro/clean, unknown?):

Purchased feed (t DM): Pasture hay Lucerne hay

Pasture silage Cereal/maize silage Grain/conc.

By-products- type and amount

Herd information

Milk production:

Annual milksolids (t):		Ave. lactation length (days)	
Ave. litres/day		or Ave. MS %	

Herd details:

	Milkers	Heifers 0-1	Heifers 1-2	Young bulls	Mature bulls
Number					
Weight (kg)					
Weight gain (kg/day)	n/a				n/a

Nutritional details: Milkers (seasonal) DMD- dry matter digestibility, CP- crude protein

		Spring	Summer	Autumn	Winter
Pasture	Amount (kg DM/day)				
	DMD & CP %				
Conc or grain	Amount (kg DM/day)				
	DMD & CP %				
Silage	Amount (kg DM/day)				
	DMD & CP %				
Hay	Amount (kg DM/day)				
	DMD & CP %				
By-product	Amount (kg DM/day)				
	DMD & CP %				
Other	Amount (kg DM/day)				
	DMD & CP %				
Other	Amount (kg DM/day)				
	DMD & CP %				

All other stock classes (annual) DMD- dry matter digestibility, CP- crude protein

		Heifers <1	Heifers >1	Young bulls	Mature bulls
Pasture	Amount (kg DM/day)				
	DMD & CP %				
Conc & grain	Amount (kg DM/day)				
	DMD & CP %				
Silage	Amount (kg DM/day)				
	DMD & CP %				
Hay	Amount (kg DM/day)				
	DMD & CP %				
By-product	Amount (kg DM/day)				
	DMD & CP %				
Other	Amount (kg DM/day)				
	DMD & CP %				

Appendix 2: Average dry matter %, dry matter digestibility and crude protein % figures for various feed sources (data sourced from the Diet Check program, referencing feed quality data from FEEDTEST, DPI Victoria).

	Dry matter %			Dry matter digestibility %			Crude protein %		
	Average	Range		Average	Range		Average	Range	
Barley grain	88.7	81.2	97.0	79.5	55.6	87.3	10.8	6.3	19.0
Barley hay	87.0	66.1	93.7	56.9	27.2	72.4	8.2	1.2	14.6
Barley silage	39.0	20.9	64.3	58.8	35.6	74.3	10.7	5.5	22.9
Barley straw	89.3	73.4	93.6	42.0	14.2	55.0	2.8	0.2	28.8
Brewer's grain	28.2	13.9	60.6	69.8	53.7	90.5	21.6	9.8	28.8
Canola meal	90.5	87.4	93.5	78.2	63.4	102.1	37.5	27.4	42.1
Carrot pulp	10.0	8.0	15.5	82.1	56.9	91.8	9.8	6.5	15.3
Citrus pulp	14.3	10.6	17.3	83.4	62.1	93.7	8.6	6.0	11.9
Cottonseed meal	89.8	87.5	95.3	71.8	62.1	82.1	43.5	39.5	48.0
Clover hay generic	86.6	61.3	93.2	57.5	40.1	72.4	17.6	6.3	26.1
Clover silage generic	41.9	20.9	79.5	62.1	52.4	68.5	19.3	12.4	27.2
Grape marc	55.1	19.6	93.9	40.7	14.9	78.2	12.1	5.4	17.2
Grass hay	86.3	51.9	94.0	51.7	31.7	67.9	8.0	0.7	17.7
Grass silage	43.2	17.1	89.3	60.1	31.0	77.6	13.2	5.1	26.6
Legume/grass silage (grass domi)	86.4	45.2	95.9	56.9	33.6	73.7	14.5	4.1	25.4
Legume/grass silage (legume dom.)	42.1	13.7	68.3	60.8	38.1	73.7	16.0	7.3	28.6
Lucerne hay	87.8	36.0	96.1	60.1	34.3	73.1	18.9	5.7	29.7
Lucerne silage	49.5	15.8	87.7	60.8	31.0	70.5	20.0	5.3	32.1
Lucerne straw	86.1	68.2	93.4	36.9	27.8	44.0	8.9	5.9	14.1
Lupin seed	91.6	86.1	95.5	81.5	72.4	96.3	32.0	21.3	43.2
Maize grain	84.2	60.3	96.4	89.2	79.5	96.3	10.0	7.3	21.9
Maize silage	30.9	9.2	84.5	68.5	32.3	84.0	7.7	3.4	17.1
Oats	91.1	80.0	93.3	66.6	38.1	91.8	9.0	4.0	15.4

	Dry matter %			Dry matter digestibility %			Crude protein %		
	Average	Range		Average	Range		Average	Range	
Oaten hay	88.9	40.2	96.4	54.3	29.1	73.1	6.9	1.1	16.3
Oaten silage	40.9	18.1	82.2	56.2	38.1	72.4	9.8	3.8	19.4
Oaten straw	89.4	80.2	93.8	40.1	27.8	64.7	2.8	0.1	11.9
Pasture hay	86.2	48.6	95.5	54.3	34.3	72.4	10.8	1.7	30.0
Pasture silage	43.1	10.9	87.6	60.8	14.2	76.3	14.1	3.2	27.3
Persian clover hay	85.6	67.8	93.5	62.1	45.3	75.6	16.2	5.3	23.3
Persian clover silage	42.9	23.7	81.9	64.0	53.0	72.4	17.6	8.0	23.4
Rice bran	90.4	89.9	90.8	89.9	60.1	97.6	15.5	12.9	19.6
Rice straw	85.2	52.2	93.5	43.3	34.3	57.5	4.0	1.9	5.0
Sorghum grain	89.6	86.2	94.4	86.0	80.8	93.1	10.6	9.6	13.2
Soyabean meal	85.4	11.9	93.7	96.3	86.0	104.7	43.5	29.3	53.7
Sub clover hay	86.8	71.7	93.9	56.9	42.0	68.5	17.2	7.7	25.7
Sub clover silage	37.1	20.6	59.9	61.4	33.6	67.9	18.8	12.6	26.9
Sunflower meal	90.8	86.4	92.0	64.0	54.3	90.5	34.1	20.4	39.1
Tomato pulp	27.3	16.6	30.2	49.8	26.5	60.1	19.4	5.0	22.6
Triticale grain	89.4	80.3	96.9	84.0	75.0	87.3	11.4	6.6	18.8
Triticale hay	86.6	54.3	93.9	55.6	31.0	69.2	7.3	1.3	16.2
Triticale silage	42.9	20.1	71.0	58.8	45.9	72.4	10.8	4.0	24.0
Triticale straw	89.8	62.7	95.7	40.1	26.5	58.2	2.8	0.7	6.7
Turnip tops*	29.1	8.5	87.7	86.6	69.2	93.7	15.9	7.2	29.6
Turnip bulbs*	23.7	4.7	87.4	89.9	75.6	95.7	14.8	4.6	26.7
Wheat bran	34.0	15.1	89.6	77.6	70.5	85.3	17.9	8.4	29.8
Wheat grain	89.4	80.2	92.9	84.7	67.9	91.2	12.9	7.4	22.7
Wheat hay	87.9	46.8	95.1	56.2	31.7	71.1	8.2	0.1	17.4
Wheat silage	44.9	27.5	69.1	56.9	29.7	69.2	10.0	6.5	16.0